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Feasibility Study. Fly Ash Reclamation of Surface Mines, Hillman State Park

Ackenheil and Associates Geo Systems, Inc, Pittsburgh, Pa

Prepared for

Industrial Environmental Research Lab, Cincinnati, Ohio Extraction Technology Branch

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The feasibility study results indicate this demonstration project would be technically feasible and the reclamation would be effective to produce useable land and improve water quality. Alkalinity in the tributaries affected by the demonstration project should increase approximately 200 milligrams per liter. The estimated cost of the demonstration construction project is about $900,000 for restoration of surface drainage to the 340 acre (138 hectare) site. Fly ash will be applied to approximately 180 acres (73 hectares) of the site which are being regraded and revegetated at an approximate additional cost of $70,000.

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FEASIBILITY STUDY
FLY ASH RECLAMATION OF SURFACE MINES
Hillman State Park

by

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Grant Number S-802526

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This report has been reviewed by the Industrial Environmental Research Laboratory-Cincinnati, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

When energy and material resources are extracted, processed, and used, these operations usually pollute our environment. The resultant air, land, solid waste and other pollutants may adversely impact our aesthetic and physical well-being. Protection of our environment requires that we recognize and understand the complex environmental impacts of these operations and that corrective approaches be applied.

The Industrial Environmental Research Laboratory - Cincinnati assesses the environmental, social and economic impacts of industrial and energy-related activities and identifies, evaluates, develops and demonstrates alternatives for the protection of the environment.

This feasibility report documents a method for the productive use of fly ash as a soil supplement for regraded acidic strip mine spoils on which re-establishment of a vegetative cover with a high survival rate is desired. The addition of fly ash to the upper layer of strip mine spoil should also retard water infiltration into acidic spoils and provide alkalinity reservoirs for the surface water which would percolate through the spoils, thereby improving the acid mine drainage pollutants discharging from within the spoils.

Results of this work will be especially interesting to State and Federal agencies concerned with reclamation of abandoned mines to produce useable land and improve water quality.

David G. Stephan, Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

The study was performed to determine the technical and economic aspects of surface treatment of regraded acidic strip mine spoils with pulverized fuel fly ash as a method to produce a soil cover which will sustain grasses and legumes and also enhance abatement of mine drainage. Data on present stream water quality of Hillman State Park was obtained to establish a set of parameters which will be used for comparison with future water quality analysis in order to determine effects of construction and the application of fly ash to the water quality. Other criteria used in this evaluation include: pH of strip mine spoil material and fly ash; moisture retention characteristics of spoils and spoils treated with fly ash; and grain size distribution of spoils and spoils treated with fly ash.

The feasibility study results indicate this demonstration project would be technically feasible and the reclamation would be effective to produce useable land and improve water quality. Alkalinity in the tributaries affected by the demonstration project should increase approximately 200 milligrams per liter. The estimated cost of the demonstration construction project is about $900,000 for restoration of surface drainage to the 340 acre (138 hectare) site. Fly ash will be applied to approximately 180 acres (73 hectares) of the site which are being regraded and revegetated at an approximate additional cost of $70,000.

This report was submitted in partial fulfillment of Environmental Protection Agency, Project S-802526, by Ackenheil & Associates Geo Systems, Inc., under sponsorship of the Environmental Protection Agency and the Commonwealth of Pennsylvania Department of Environmental Resources.

CONTENTS

		Page
Foreword		iii
Abstract		iv
Tables		vii
Figures		viii
Acknowledgments		ix
Section		
I	Conclusions	1
	Technical Feasibility Impact on Water Quality Economic Considerations	
II	Recommendations	3
	Proceed with the Demonstration Project	
III	Introduction	4
	General Objectives and Scope Jurisdictional Framework	
IV	Description of Project Area	10
	Location Site Topography Geology Mining History	

CONTENTS CONTINUED

Section		Page
V	Data Obtained During Phase I	18
	Water Quality Study Strip Mine Spoil Fly Ash Strip Mine Spoil - Fly Ash Mixtures	
VI	Fly Ash Application Considerations.	46
	Neutralization Variables Economic Variables Method of Application	
VII	Proposed Plans for Project Implementation	48
	Construction Plans Sequence of Construction Fly Ash Application Methods and Rate Seeding Sampling and Testing Continuing Water Quality Monitoring	
VIII	Cost Estimate	54
	Summary of Estimated Costs to Complete Project Construction Costs Estimate Fly Ash Estimate Construction Design Costs Engineering Costs for the Demonstration Portion	
IX	Appendix	57
	Individual Station Water Quality Data	

TABLES

No.		Page
1	Water Quality Sampling Stations	20
2	Water Quality Summary	28
3	Spoil pH	30
4	Mechanical Analysis - Soil Classification of Spoils	30
5	Spoil Limestone Requirements	31
6	Chemical Analysis of Strip Mine Spoils	32
7	Fly Ash - Spoil Moisture Retention Test Results	33
8	Chemical Analysis of Fly Ash Samples	34
9	Fly Ash Neutralization Capacity	37
10	Fly Ash Transportation Cost Estimate	37
11	Estimate of Construction Costs	55

FIGURES

No.		Page
1	Location Map	11
2	Hillman State Park Boundary Map	12
3	Demonstration and Reclamation Project Areas	13
4	Topographic Map (1972) Hillman State Park.	14
5	Structural Contour Base of Pittsburgh Coal	16
6	Subwatershed Areas, Principal Streams and Sampling Stations	19
7	Water Quality Data, Stations 2, 4B and 6	24
8	Water Quality Data, Stations 10, 10A, 12 and 16	25
9	Water Quality Data, Stations 17, 17A and 18A	26
10	Water Quality Data, Stations 32, 35 and 40	27
11	Location of Fly Ash Sources	36
12	pH of Various Spoil - Fly Ash Mixtures	40
13	pH of Various Spoil - Fly Ash Mixtures	41
14	pH of Various Spoil - Fly Ash Mixtures	42
15	pH of Various Spoil - Fly Ash Mixtures	43
16	pH of Various Spoil - Fly Ash Mixtures	44
17	Fly Ash Application Rate	45
18	Reclamation Design Example	49

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SECTION I

CONCLUSIONS

The following conclusions are the opinion of the Consultant. They are based on the data obtained during Phase I as presented in Section V and based on the study leading to the project implementation plans presented in Section VII.

TECHNICAL FEASIBILITY

Basis: The project is technically feasible on the basis of the following:

The strip mine spoils at the demonstration site contain unoxidized pyrite material and are therefore capable of producing acid mine drainage (AMD).

The spoils, because of color, texture and acidity, are detrimental to the establishment of a cover of grasses and legumes considered necessary to resist erosion and reduce stream pollution potential.

Fly ash and spoil mixtures are favorable because the acidic materials in the spoils can be successfully neutralized with a specified fly ash addition. The moisture retention characteristics of the spoil will also be improved with the addition of fly ash.

Fly ash is available locally in quantities sufficient to supply the tonnages needed for the project.

The demonstration project does not require any specialized equipment for the reclamation work or the placing and mixing of fly ash with the regraded spoils.

No easement problems are anticipated as the demonstration site is primarily owned by the Commonwealth of Pennsylvania. The few adjoining property owners affected by this project have already signed the necessary Agreements to perform the work.

The restored land will be used for recreational purposes which is in agreement with the high priority assigned to the reclamation of surface-mined land by the Department of the Interior.

The demonstration project will require a large tonnage of fly ash and thus provides a productive use of this waste by-product of coal-generated electricity.

IMPACT ON WATER QUALITY

There should be a slight increase of pH that will approximate unpolluted ground water within the demonstration area as a result of increasing the pH of the surface spoils by the addition of fly ash. Alkalinity in the tributaries affected by the demonstration project should increase approximately to 200 milligrams per liter, sulfates should remain about the same, and metal ion concentration should decrease somewhat due to their decreased solubility at the anticipated higher pH levels of the strip mine spoils. The neutralization of the upper plow depth should result in the establishment of a high survival cover of grasses and legumes which, in turn, should retard water infiltration into the acidic spoils and reduce erosion.

ECONOMIC CONSIDERATIONS

Budget for Project Completion: The cost budget ($620,830) in the grant application is shared between the Commonwealth of Pennsylvania ($320,830) and the Environmental Protection Agency ($300,000). The size of the demonstration area has been expanded to include additional areas for reclamation and all original costs have increased due to inflation. However, it is assumed that the Commonwealth can fund the additional monies required to accomplish this project without increasing the Environmental Protection Agency's share of the grant application ($300,000). The estimated cost to accomplish this project is presented in Section VIII and summarized as follows:

Construction Cost, estimated at:	$ 900,000
Engineering Costs, estimated at:	$ 66,500
Fly Ash Cost, estimated at:	$ 70,000
TOTAL ESTIMATED BUDGET TO COMPLETE:	$1,036,500

Estimated salaries and expenses for the Commonwealth of Pennsylvania are not included in the above. The above cost also does not include services for construction design which is being performed simultaneously with Phase I of this project under Contract No. SL 130-2-1 with the Commonwealth of Pennsylvania.

Comparable Cost for Limestone: The use of limestone on a comparable basis of treatment with fly ash would result in an estimated total cost of $28,480. This is based on a unit cost of $160 per acre ($396 per hectare) using 5 tons of limestone per acre (11.2 metric tons per hectare) over the 178 acre (72 hectare) site. Although the initial application costs of limestone may be more economical, the benefits of the limestone on the acidic spoils may not be as long lasting as the benefits derived from the use of fly ash. Mixing the large quantities of fly ash with spoil will increase the pore volume, moisture availability, and the air capacity, thus improving conditions for root penetration and growth.

SECTION II

RECOMMENDATIONS

Based on the conclusions of the preceding section, the following recommendations are presented to the Commonwealth of Pennsylvania.

PROCEED WITH THE DEMONSTRATION PROJECT

Basis: Proceed with Phase II and Phase III of the demonstration project on the basis of the following:

The project is technically feasible.

The project can be performed within the estimated cost presented in Section VIII without requiring the U. S. Environmental Protection Agency to provide additional monies beyond that appropriated in the original grant application.

The project will improve the water quality draining from the demonstration area, produce a more suitable soil cover to encourage grass and legume vegetation, and utilize an abundant solid waste.

SECTION III

INTRODUCTION

GENERAL

Demonstration Project Feasibility Report: This report discusses the feasibility of performing a "Fly Ash" demonstration project in Washington County, Pennsylvania.

Work on the feasibility portion of the project has been in progress since April 1, 1974. Initiation of work followed a grant offer from the Environmental Protection Agency (EPA) to the Commonwealth of Pennsylvania on March 15, 1974 and subsequent acceptance of that offer by the Commonwealth of Pennsylvania. The grant for the Demonstration Project is covered under Section 107 of the Federal Water Pollution Control Act and is assigned Project No. S-802526.

The total project, scheduled over a three-year period, is broken into three distinct work phases. Phase I involves a feasibility study, Phase II includes design and construction operations, and Phase III permits post-construction evaluation. This report describes results of Phase I which has been completed.

Acid Mine Drainage Pollution Abatement: Oxidation of the impurities in the coal and associated coal measure rocks exposed during mining is one of the major deteriorating effects on the land surface and stream environment that result from the mining of coal.

Current mining and water quality laws require the states to obtain EPA discharge permits and submit plans of mining operations directed toward minimizing the effects of siltation and acid mine drainage pollution during active mining. Reclamation of strip-mined land can be accomplished in such a manner that future discharge of acid mine drainage will be minimal.

Abandoned strip mines are particularly troublesome sources of acid mine drainage (AMD) into streams of coal-producing regions. Determining ownership, fixing responsibility and formulating legislation requiring abatement of abandoned strip mines is difficult or impossible. Usually pollutants from such sources are truly "orphans."

Fly Ash Treatment of Strip Mine Spoils as a Method of Acid Mine Drainage Pollution Abatement: Various techniques have been developed and demonstrated for the abatement of acid mine drainage from abandoned strip mines. Some of the techniques to reduce infiltration of water and air into the strip mine spoil include: contour and terrace backfilling of the strip mines; diversion of water on the surface around the strip mine spoils; and revegetation with various grasses, legumes and trees. However, the establishment of a vegetative cover on highly acidic strip mine spoils is difficult and has usually resulted in a low survival rate for the grasses, legumes, and trees.

The lack of vegetation results in erosion of the spoils; thus, re-exposing the pyritic material within the strip mine spoils to air and water. The low survival rate is probably due to the neutralization and leaching of the alkaline soil additives and re-establishment of the acidic nature of the spoils. A second major factor contributing to a low survival rate is the low moisture retention rate for coarse grain strip mine spoils. Treatment of the upper layer (root zone) of the strip mine spoil with pulverized fuel-fly ash should accomplish the following:

Raise the pH of the spoils to a level which will promote the growth of plants and legumes.

Add fine grain size material to the coarse grain spoils and thus increase the moisture retention of the spoils.

Provide alkalinity reservoirs for the surface water percolating through the spoils. This could result in some additional neutralization of toxic spoils below the treated depth and also result in an improvement in the quality of the water discharged from within the spoils.

Provide a stable vegetative cover that could reduce the movement of water and oxygen to the pyritic material in the spoils, thus resulting in a reduced production of AMD underlying untreated spoil material.

Provide a productive use for fly ash, which currently has limited use in comparison with its availability, and creates a disposal problem.

Requirements for Fly Ash Treatment: The technique of fly ash treatment of strip mine spoils as a method of acid mine drainage abatement is potentially applicable to abandoned strip mines in the United States. Regrading of these abandoned strip mines usually does not involve segregation of the toxic material from others due to the expense. These regraded strip mines could contain a surface on which the toxic material is exposed and the spoil texture is generally coarse grained. Both of these factors result in low survival rate for grasses and legumes. Thus, in a short period of time, the bare spoil is subject to erosion and additional pyritic materials are exposed to air and water resulting in the production of AMD.

The choice between the use of fly ash and other materials such as slag, limestone, or fine grained soils to improve the quality of the spoils should be based on the relative costs and effectiveness of the various techniques. The feasibility of the use of fly ash as an additive to the strip mine spoils should depend on transportation costs of the fly ash to the site and the characteristics of the strip mine spoils. In addition, the use of fly ash depends upon the "buffer" capacity (lime equivalent or neutralization potential) of the fly ash and cost to obtain the fly ash in large quantities. The local producers of fly ash contacted in the tri-state area (Western Pennsylvania, Northern West Virginia and Southeastern Ohio) have indicated their willingness to donate fly ash at the time of this report. However, fly ash could be a saleable product in a few years.

In addition to the reduction of AMD pollution from strip mines, the use of fly ash can result in the establishment of a long lasting growth of grasses or legumes on strip mine spoils and can be considered an aesthetic benefit. The reduction of siltation is also an added benefit which could contribute greatly to the re-establishment of the aquatic life in the streams formerly degraded by AMD and siltation from abandoned strip mines.

The above three requirements are considered applicable to Hillman State Park.

OBJECTIVES AND SCOPE

Objectives: The principal objective of this project in the Hillman State Park area is to demonstrate how fly ash can be used successfully to improve soil conditions, promote long term growth of vegetative cover on strip-mined reclamation areas, and reduce the production of acid mine drainage.

The physical, social, and economic problems related to the objective of the demonstration are itemized as follows:

Most streams in Hillman State Park do not comply with Commonwealth of Pennsylvania water quality standards.

The park is to serve as a recreation facility for Commonwealth residents, but the disrupted land area, in addition to the substandard water quality, makes the region undesirable in many respects from environmental and aesthetic viewpoints.

The disposal of fly ash, a by-product from coal-fired power plants, is becoming a serious national disposal problem and uses for large quantities of this product are actively being sought. At present, better than 30 million tons (27 million metric tons) of fly ash are produced annually, but only a fraction of this tonnage is utilized effectively. On a broad scale, the proposed demonstration is directed toward solution of the above problems. More specifically, the project will consist of selecting a

demonstration area, preparing the area to be treated, applying fly ash to the chosen area, and evaluating results following construction by comparisons with non-fly ash work areas.

Scope of Work to Date: A pre-feasibility study conducted jointly by the Commonwealth of Pennsylvania and the Consultant involved:

Conferring with the Commonwealth of Pennsylvania and the Environmental Protection Agency to discuss the scope of the demonstration and the selection of the most probable demonstration site.

A review of Hillman State Park Mine Drainage Survey Project SL 130-2, which was prepared by the Consultant, to determine the suitability of a portion of the site for the demonstration area.

A review of the literature on the use of fly ash as a soil modifier.

Determining the possible sources of fly ash and the interest of fly ash producers in such a demonstration project.

Based on the information obtained, an application was submitted to the Environmental Protection Agency for the Demonstration Project Grant by the Commonwealth of Pennsylvania.

Following the award to the Commonwealth of Pennsylvania, a grant for a Demonstration Project, Phase I of the project was undertaken. The purpose of Phase I was to determine the feasibility of performing the project from a technical and economical standpoint as indicated in the grant, to obtain data on which to base detailed construction plans and specifications, and to establish a program of water quality monitoring. The scope of Phase I is generalized as follows:

Confer with the U. S. Bureau of Mines, Morgantown, West Virginia to obtain information and advice on the use of fly ash in reclamation work.

Obtain samples of the spoil materials in the proposed fly ash treatment areas. Perform chemical analysis tests on spoil, perform laboratory tests on combined mixtures of spoil with fly ash to estimate resultant spoil characteristics and establish tentative fly ash treatment areas.

Identify possible fly ash sources and obtain samples for chemical analysis and testing with spoil materials, evaluate the fly ash transportation costs, and on the basis of cost and laboratory test results, select a fly ash source for the project.

Recommend a plan for fly ash application and estimation of quantities and costs for fly ash.

Establish a weekly sampling schedule at the selected water quality monitoring stations and perform laboratory tests on these samples to include pH, acidity, alkalinity, total iron, sulfates, aluminum, and manganese, along with constructing and installing a continuous monitor.

Prepare a report presenting the results of the above investigations and recommendations on the feasibility of the project.

JURISDICTIONAL FRAMEWORK

Cognizant Authority: This project is being undertaken by the Department of Environmental Resources of the Commonwealth of Pennsylvania.

Legislation: The legislation authorizing the expenditure of funds for this project is Act 443, the Land and Water Conservation and Reclamation Act of January 19, 1968, Section 19 of the Commonwealth of Pennsylvania Code.

Contracting Agency: The contracting agency for this project is the Department of Environmental Resources, Commonwealth of Pennsylvania.

Administrative Agency: The work under contracts for this project will be administered by the Department of Environmental Resources of the Commonwealth of Pennsylvania.

Water Quality Standards: Water quality standards which regulate discharge into any of Pennsylvania waters have been established by the Department of Environmental Resources. Water quality in the streams of Pennsylvania is regulated under Title 25, Rules and Regulations, Department of Environmental Resources, as amended, and thus prevents degradation of the water quality due to future mining or construction operations.

Higher Public Use of Waters: No legislation relative to the higher public use of water is known to have bearing on the fly ash demonstration project. Since no dams or impoundments other than the siltation basins are involved, no permits would be required. No diminishing of the quantity of water in any project area will occur and thus no riprapian water rights are involved.

Land Use Standards: No particular land use standards are known to exist for the general area in which the project site is situated. It is proposed that the project site is to be returned for use as a public park to the Commonwealth of Pennsylvania and be under the administration of the Bureau of State Parks.

Site Acquisition: The project site is predominantly owned by the Commonwealth of Pennsylvania. Certain portions of the project area, however, are on private property. The Land Easement Branch of the Department of Environmental Resources has obtained suitable Agreements of easement to satisfy the requirements established by the Commonwealth of Pennsylvania.

Funding Authority: The Funding Authority for this project is the Department of Environmental Resources of the Commonwealth of Pennsylvania, as indicated previously in the description of the effecting legislation.

Water and Mineral Rights: No water rights will be affected by the project. Discharge from the project site enters tributaries which eventually flow into Raccoon Creek which is located outside of the boundaries of the Hillman State Park.

Commonwealth Ownership of Land: The ownership or easement of the Project Land by the Commonwealth of Pennsylvania will give control of any future pollution from the project site to the Commonwealth of Pennsylvania.

Existing Mining Laws and Water Quality Standards: The existing mining laws and water quality standards of the Commonwealth of Pennsylvania regulate discharge from future mining activities and these regulations will effectively control possible future pollution of Hillman State Park from any new mining operation.

Mining on State Owned Lands: No future mining within the boundaries of Hillman State Park is anticipated.

SECTION IV

DESCRIPTION OF THE PROJECT AREA

LOCATION

Hillman State Park is located in Hanover Township, Washington County, Pennsylvania. The central portion of the park is situated approximately 20 miles (32 kilometers) west of Pittsburgh and about 8 miles (13 kilometers) east of Weirton, West Virginia (Figure 1).

The park area is located within a region generally bounded by U. S. Route 22, U. S. Route 20 and Pa. Route 18. U. S. Route 22 forms the southern boundary of the park between the towns of Bavington and Florence. The total surface area of Hillman State Park is 3,654 acres (1,479 hectares) or approximately 5.7 square miles (14.8 square kilometers). As indicated on the Hillman State Park Boundary Map, Figure 2, an approximate 200 acre (80 hectares) tract of land within the central portion of the park is privately owned.

SITE

The demonstration project area is in the northwestern section of the park and encompasses approximately 340 acres (138 hectares) of subwatersheds which are isolated and not surface drained by the local streams. These undrained subwatersheds trap surface runoff water which subsequently filters through the spoils reaching the bottom coal elevation and eventually moves along the coal structure discharing as AMD at downdip locations. Regrading will be required on approximately 180 acres (73 hectares) in order to provide positive surface drainage of these 340 acres (138 hectares) of undrained land within the demonstration area. The relationship of the demonstration area to other reclamation areas of the park is shown on Figure 3.

TOPOGRAPHY

Essentially all of the Pittsburgh coal reserve has been removed from the Hillman State Park area by surface mining methods. No highwalls exist since most hills were removed or covered in total during the stripping operations. Although most areas of the park region were reclaimed during mining, the natural topography of much of the area has been significantly altered. As a result, large land areas are not adequately drained. The current landscape appears to have been "area" mined as might normally be the case in many western regions of the United States. In this respect, the Hillman area is unique to Western Pennsylvania or the Appalachian

LOCATION MAP

Reproduced from best available copy.

FIGURE 1

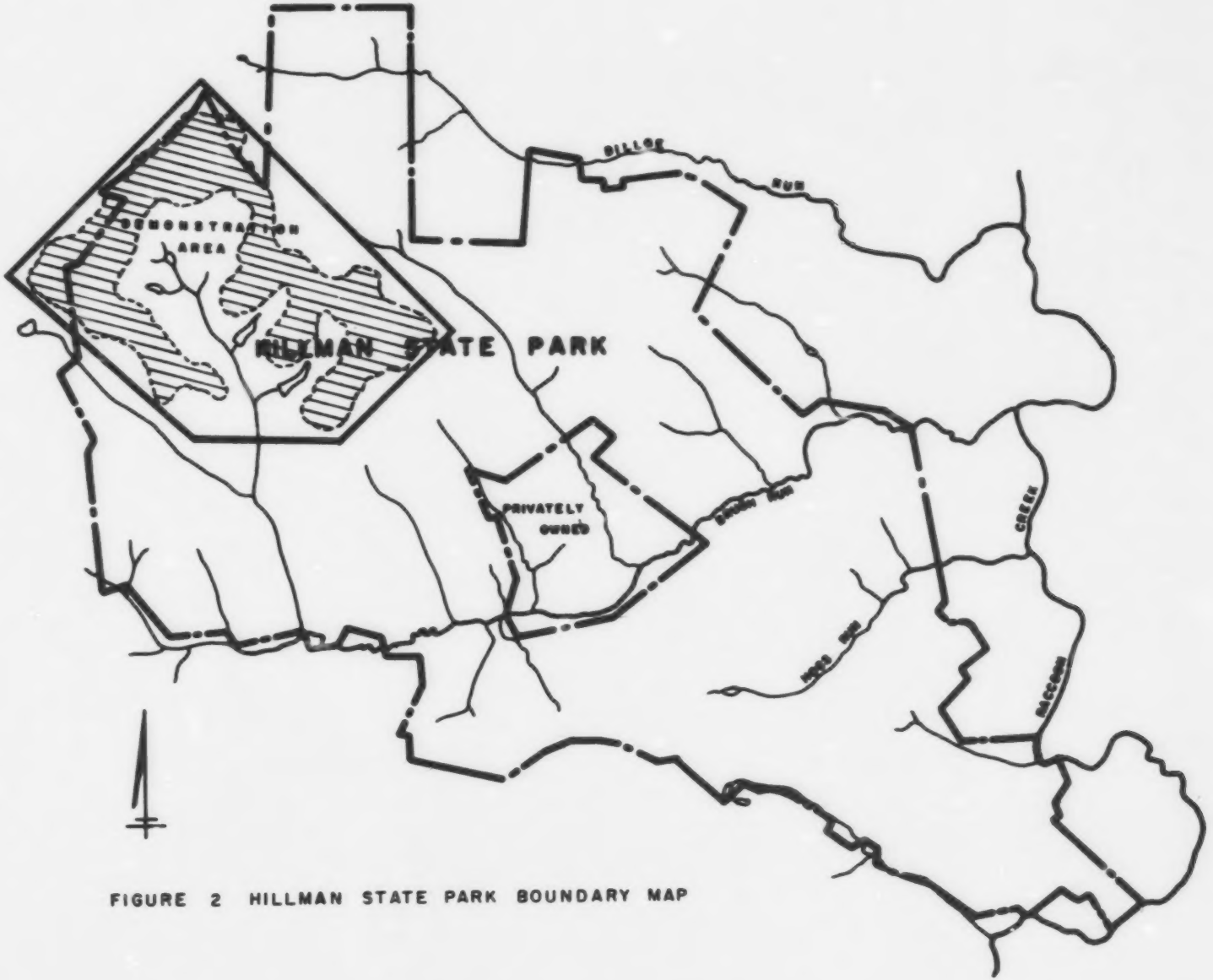

FIGURE 2 HILLMAN STATE PARK BOUNDARY MAP

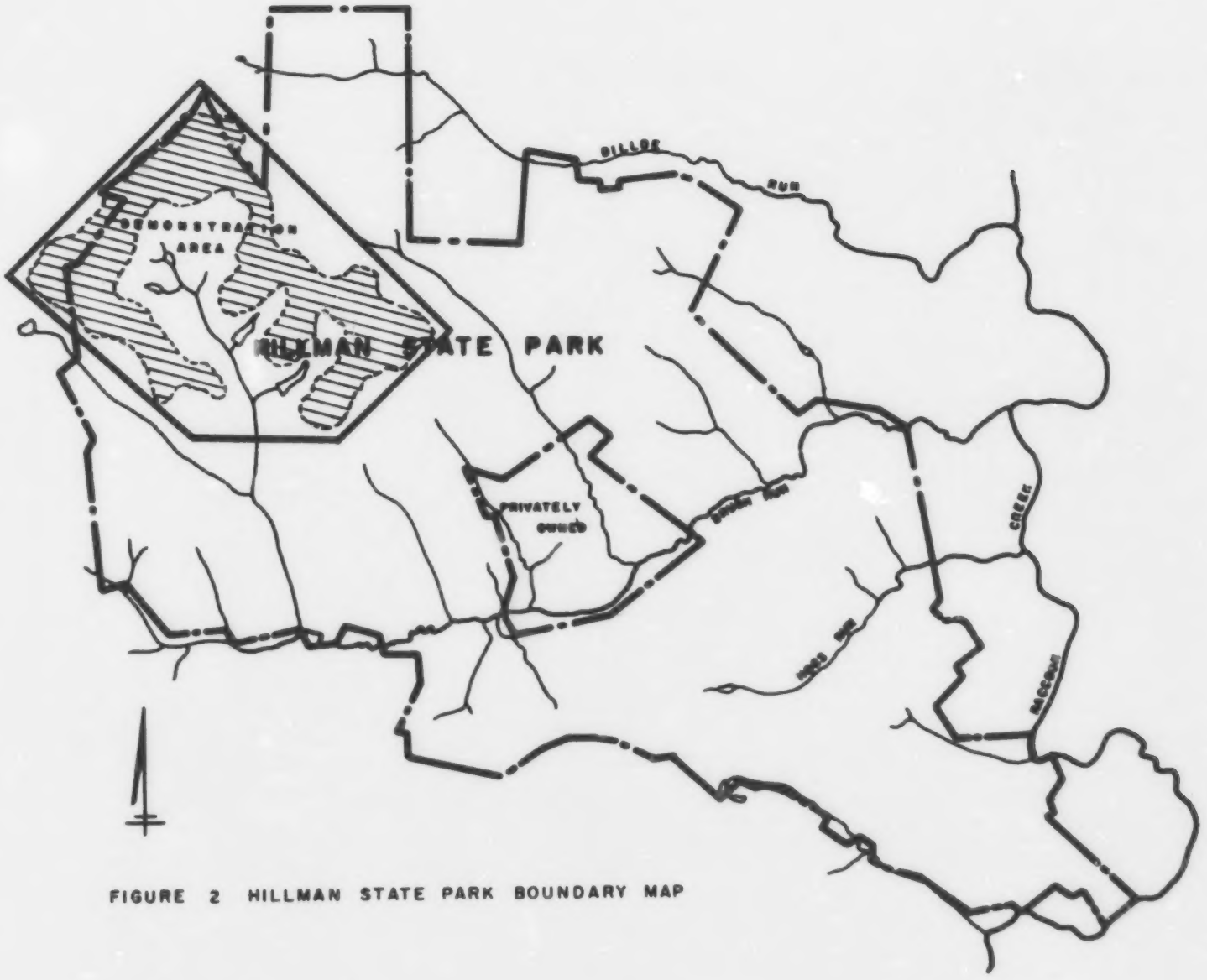

FIGURE 2 HILLMAN STATE PARK BOUNDARY MAP

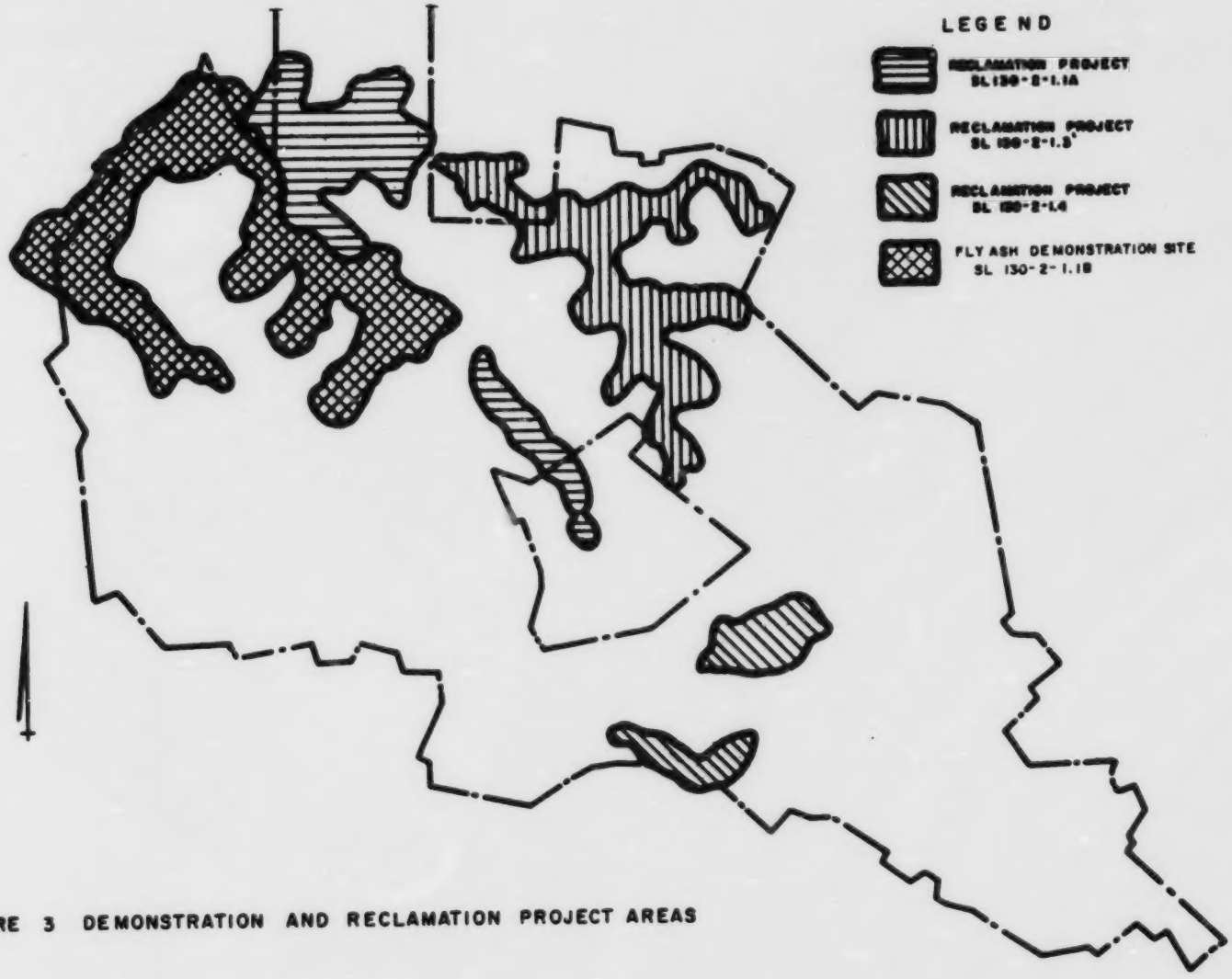

FIGURE 3 DEMONSTRATION AND RECLAMATION PROJECT AREAS

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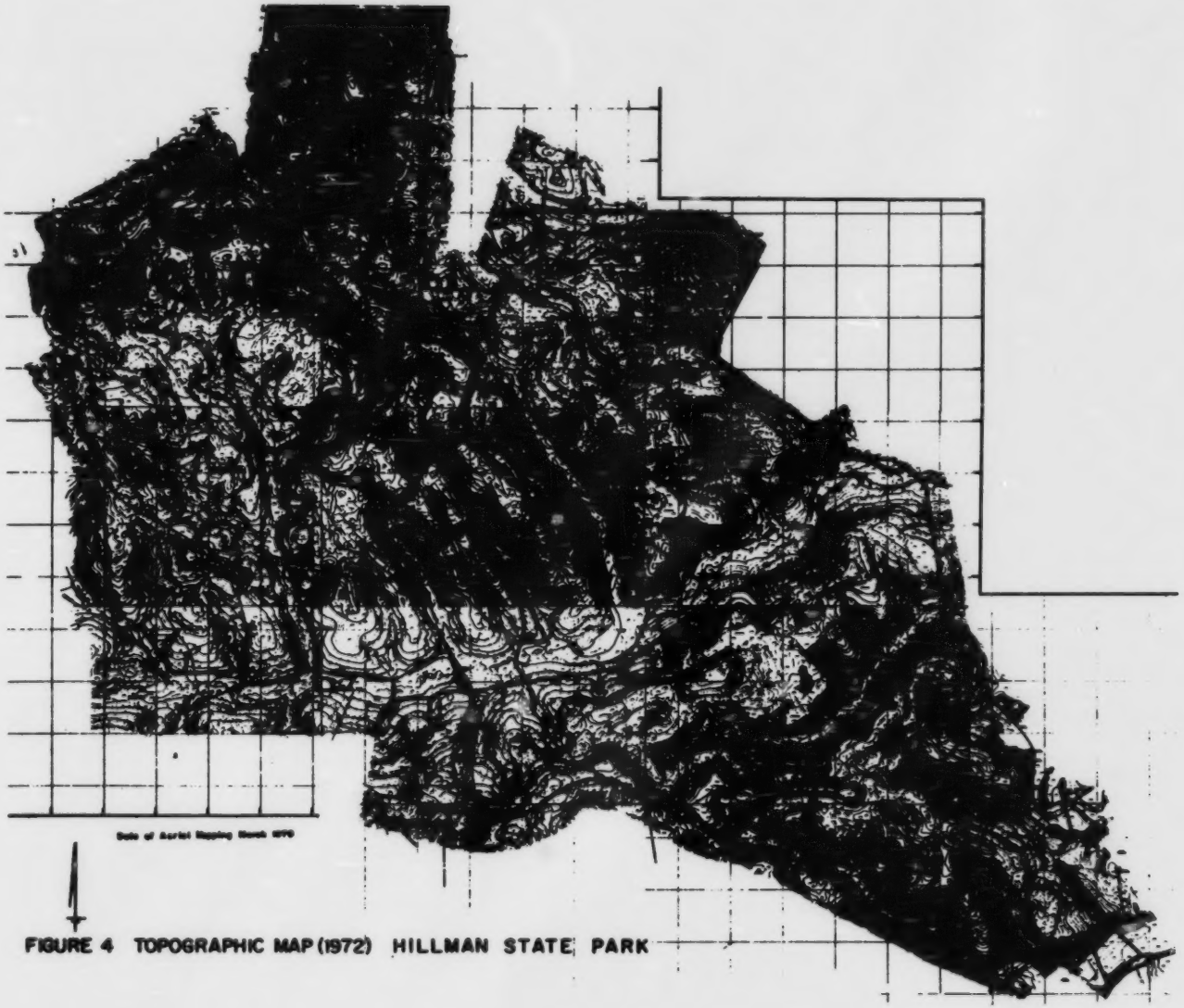


FIGURE 4 TOPOGRAPHIC MAP (1972) HILLMAN STATE PARK

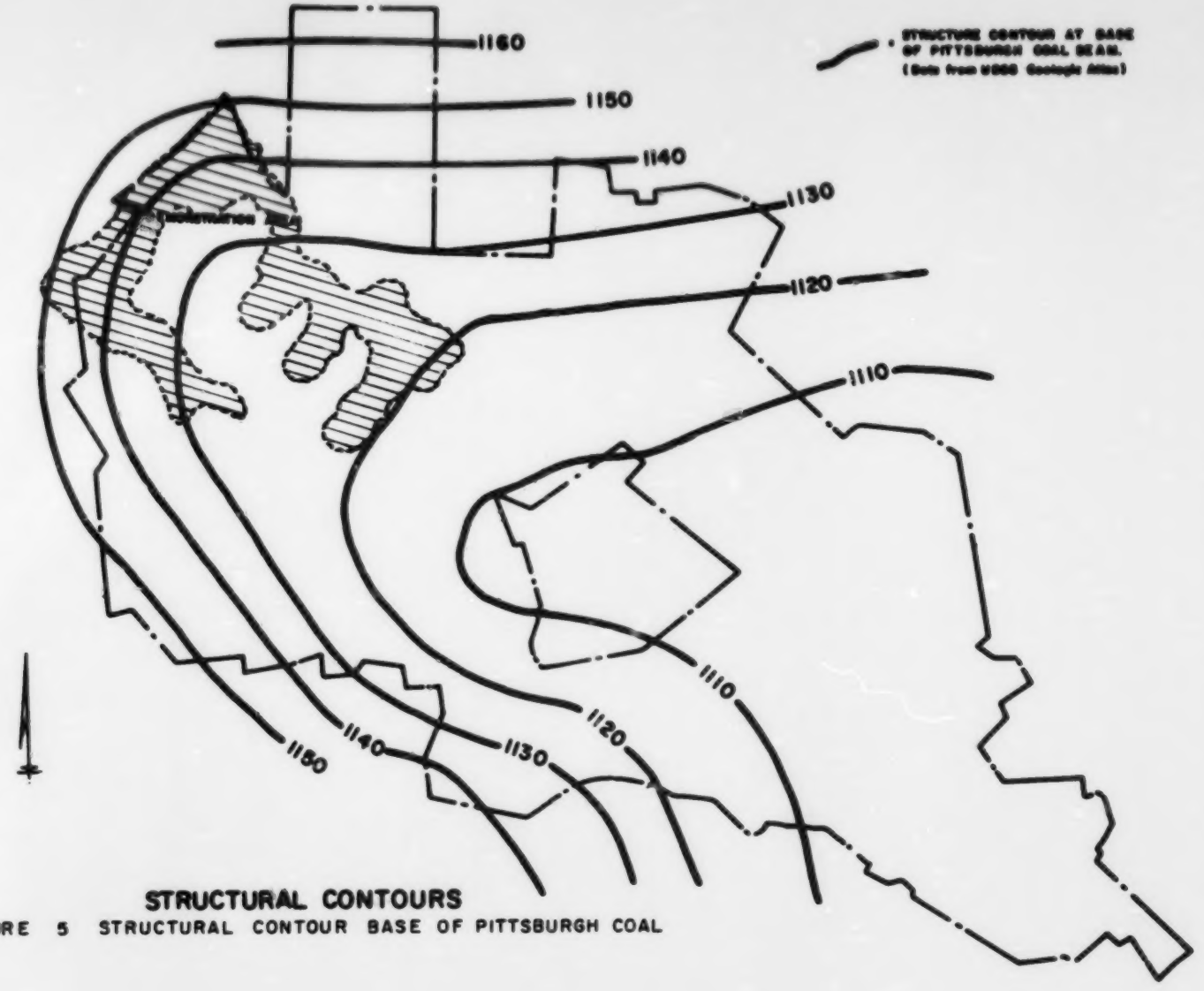
Region where contour mining is a usual situation. The existing topography as of 1972 is shown on Figure 4. The topography outside of the demonstration area has been altered recently because of abatement project construction performed under Commonwealth of Pennsylvania Projects SL 130-2-1.1A, SL 130-2-1.3 and SL 130-2-1.4. Hillman State Park is considered an ideal demonstration area in that the large majority of the work area is owned by the Commonwealth and no difficulties in dealing with private owners are anticipated. Also, the absence of deep mines in the park area provides an opportunity to evaluate surface reclamation techniques without the problems of identification and analysis that are often encountered in combined surface and deep mined areas.

GEOLOGY

Hillman State Park is contained within the geologic province known as the Appalachian Plateau. This province is characterized by essentially flat-lying strata whose regularity is broken by low, broad folds. The West Middletown Syncline is the fold which most predominantly affects the local geology of the Hillman area. The north trending axis of the syncline crosses below the eastern edge of the park near Bavington, Pennsylvania. The closure of the syncline just to the northeast of the park results in a basin-like structure within the main park area. This condition is evident by noting the circular pattern formed by the Pittsburgh Coal structural contours. Figure 5 shows the structure contours on the base of the Pittsburgh Coal as interpreted from U.S.G.S. Geologic Atlas.

The bedrock strata exposed over various portions of Hillman State Park are members of the Conemaugh and Monongahela Formations of Pennsylvanian Age. The total stratigraphic thickness exposed is on the order of 400 feet (122 meters). All of the strata are sedimentary in origin. The Conemaugh and Monongahela Formations are comprised principally of shales and sandstones, but also contain prominent limestones and coal horizons. The more important strata are the Pittsburgh Sandstone (actually sequences of shale and sandstone), the Pittsburgh Coal, the Pittsburgh Limestone (actually sequences of limestone and shale), the Connellsville Sandstone and the Morgantown Sandstone. The homogeneous nature of the bedrock overlying the Pittsburgh Coal has, however, been significantly altered by surface mining methods and the natural strata sequence above the Pittsburgh Coal now occurs only in areas where surface mining was not performed.

Strip mine backfill forms the soil cover over most of the higher elevations of Hillman State Park. This backfill cover consists principally of shale, claystone and limestone rock fragments and limited amounts of silt and clay. Residual soils (sands, clays and silts) formed by the weathering of underlying bedrock strata are the predominant soil types found along most valley slopes below the Pittsburgh Coal elevation. Alluvial, or stream deposited, clays and silts are the principal soil types present along the low, broad stream valley of Brush Run.



STRUCTURAL CONTOURS

FIGURE 5 STRUCTURAL CONTOUR BASE OF PITTSBURGH COAL

MINING HISTORY

Mining of the Pittsburgh Coal seam on the now Hillman State Park property was performed over better than a 50 year period.

Strip mining over small areas of the Hillman property was first initiated in 1914 by John A. Bell. In the early 1920's, J. R. Elec operated a small country deep mine along the northern edge of U. S. Route 22. This operation, covering an area of about 17 acres (7 hectares), is the only known mapped deep mine located inside the park boundaries. The Harmon Creek Coal Corporation purchased the majority of the Hillman Park property between the years 1935 and 1940. The Harmon operations began on a large scale in 1937 with the purchase of a 15 cubic yard (11.5 cubic meter) shovel.

Strip mining in the area moved at a significant pace during World War II. To help ease coal shortages during this period, the Harmon Creek Coal Corporation permitted a number of small coal contractors to strip mine in the area on a royalty basis. These smaller operators normally stripped horizontal distances of 25 to 40 feet (7.5 to 12 meters) into the hillsides. Harmon subsequently stripped the hilltops beyond these points.

Mining of the Hillman property continued after World War II when properties within the village of Five Points were purchased and the entire village area was strip mined. A 12 cubic yard (9.2 cubic meter) dragline, purchased in 1954, facilitated coal removal during these later years. Auger mining was performed in certain limited areas. Forty-two inch (106.7 centimeter) augers were used and auger holes generally ranged from 20 to 180 feet (6 to 55 meters) in depth. Mining operations were finally completed in 1966.

It is estimated that approximately 94% of the coal obtained from the Hillman Park property was removed by the surface stripping method. Augering and the early deep mining operation accounts for the additional 6% of coal removed. An estimate of the total amount of coal removed from the Hillman State Park property would range in the neighborhood of 15 million tons (13-1/2 million metric tons) or 98% of the estimated coal reserve initially in place. Coal remains in place in only a few isolated areas of Hillman State Park. The estimated remaining reserve, contained for the most part under three unmined hilltops, is 300,000 tons (272,000 metric tons). The amount of vertical overburden above this coal generally varies from 50 to 130 feet (15 to 40 meters). The total volume of overburden covering the 300,000 tons (272,000 metric tons) of coal is estimated to be close to 4 million cubic yards (3 million cubic meters).

SECTION V

DATA OBTAINED DURING PHASE I

The following sections present the data obtained during Phase I and indicate the method of obtaining these data:

WATER QUALITY STUDY

Demonstration Site: The subwatersheds to be included in the demonstration project were selected from an area scheduled for reclamation and are shown on Figure 6, which is a map of Hillman State Park showing the principal undrained subwatersheds and streams of the park area. The new established flow pattern for surface water from the undrained subwatersheds was plotted from a review of completed and proposed construction plans. Sample collection and flow measurements sites were selected. These stations were selected to reflect changes in water quality in the stream which occur prior to, during, and after the demonstration project. The locations of the sample stations are also shown on Figure 6.

Previous Water Quality Data: Water quality data for the Hillman State Park was obtained from Hillman State Park Mine Drainage Survey SL 130-2, dated April 14, 1972. This survey identified 24 sources of acid mine drainage; 8 of which were considered major sources. A major source in the Hillman State Park Mine Drainage Survey is designated as one which, on the average, contributes a net load of more than 350 pounds (160 kilograms) of acid per day to a receiving stream (net acid load equals acid load minus alkaline load). The locations of the previous sample points are shown on Figure 6.

Phase I Monitoring: The sampling stations at which routine samples were obtained are shown on Figure 6. The relationship of these sampling stations to the previously established sample locations is given in Table 1. The purpose of each station is also explained in Table 1.

Weirs were constructed at all sampling stations except Station 17A. Compound weirs were installed at all stations except Station 35 where a 6 foot (1.83 meter) rectangular weir was installed. No difficulty was encountered with the installation or maintenance of these weirs during the period of this study.

Samples were collected and flow measurements were taken weekly at each station commencing in mid-June, 1974. Water samples were collected in polyethylene plastic bottles. One large and one small water sample was obtained.

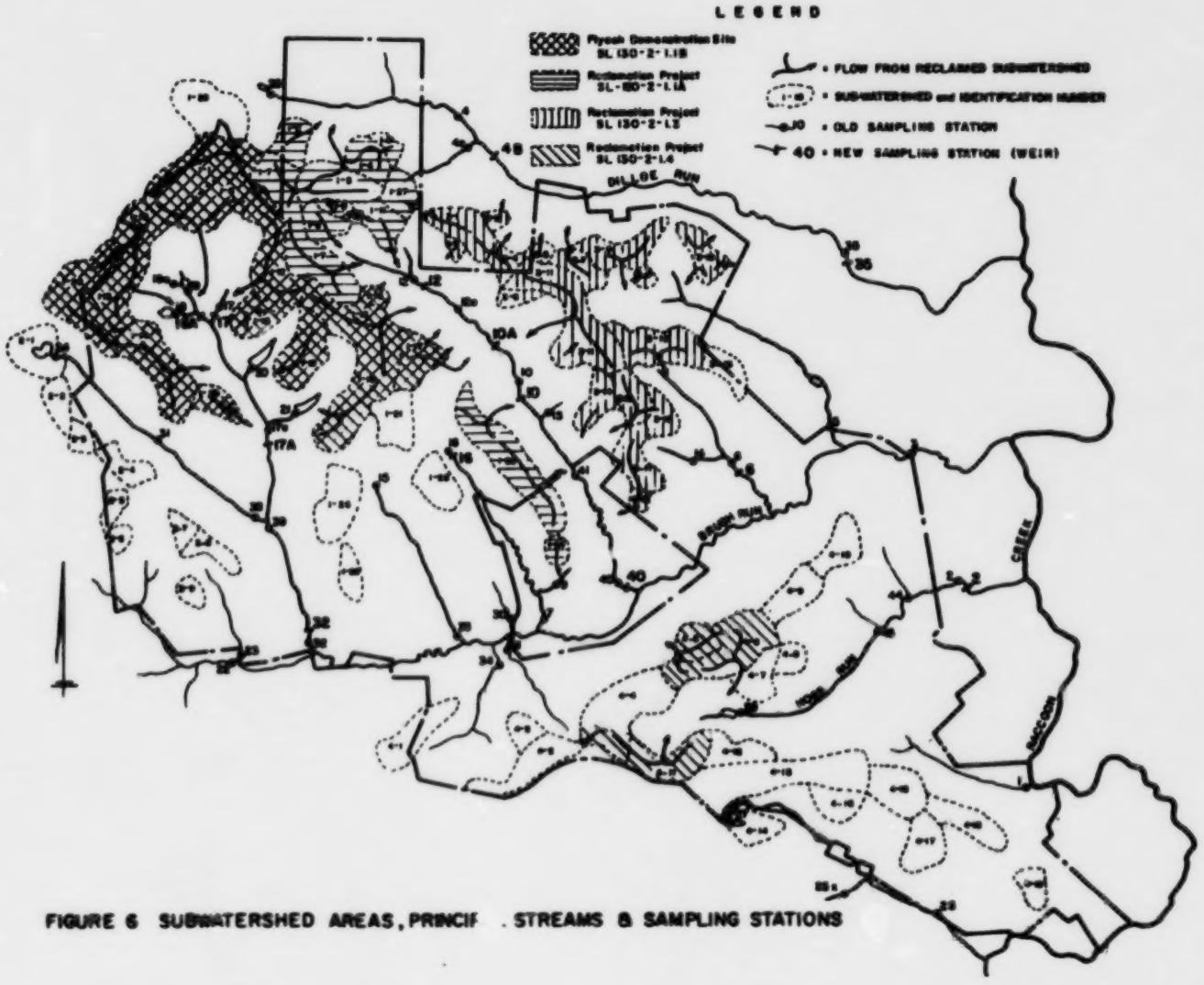


FIGURE 6 SUBWATERSHED AREAS, PRINCIP . STREAMS & SAMPLING STATIONS

TABLE 1. PHASE I - WATER QUALITY SAMPLING STATIONS

STATION NUMBER	PURPOSE	PREVIOUS WATER QUALITY DATA AVAILABLE
2	Evaluate the water quality data in Hogs Run as it would be affected by the construction project SL 130-2-1.4	9 monthly readings from November, 1970 to July, 1971
4B	Evaluate the dilution effect that the construction of Projects SL 130-2-1.1A and SL 130-2-1.3 has on Dilloe Run which is also affected by AMD flows outside of Hillman State Park	New station. Previous water quality data from Stations 4 and 4A consists of 3 monthly readings, January, 1971 to March, 1971
6	Evaluate the water quality resulting from the construction in Subwatershed 3-12	14 monthly readings from July, 1970 to July, 1971
10	Evaluate the water quality as it would be affected by the construction in Subwatershed 3-11, Project SL 130-2-1.3	14 monthly readings from July, 1970 to July, 1971
10A	Evaluate the water quality as it would be affected by the construction in Subwatersheds 1-16, 1-17, and a portion of 1-18 plus the subwatersheds monitored by Station 12	New station
12	Evaluate the water quality as it would be affected by the construction in Project SL 130-2-1.1A	12 monthly readings from October, 1970 to July, 1971

Table 1 - continued

STATION NUMBER	PURPOSE	PREVIOUS WATER QUALITY DATA AVAILABLE
16	Evaluate the changes in the water quality as a result of the construction in areas northwest of this station. This station will only monitor a source of subsurface drainage as reclamation construction to the northwest will not provide additional surface flow to this station	14 monthly readings from July, 1970 to July, 1971
17	Evaluate the water quality as it would be affected by the construction in Subwatersheds 1-12 and 1-15 of the demonstration area	14 monthly readings from July, 1970 through July, 1971
17A	Evaluate the water quality data as it would be affected by the construction in the demonstration area, including Subwatersheds 1-20, 1-14, 1-18, and a portion of 1-29 plus the subwatershed monitored by Stations 17 and 18A	10 monthly readings from October, 1970 to July, 1971
18A	Evaluate water quality as it would be affected by the construction in Subwatersheds 1-1, 1-16, 1-13 and a portion of Subwatershed 1-29 of the demonstration area	New station. Previous data available from Stations 18, 19 and 19A
32	Evaluate the water quality further downstream from the demonstration area at the mouth of this subtributary and compare it to the upstream water quality from Station 17A	9 monthly readings from December, 1970 to July, 1971

Table 1 - continued

STATION NUMBER	PURPOSE	PREVIOUS WATER QUALITY DATA AVAILABLE
35	Evaluate the dilution effect that the construction of Projects SL 130-2-1.1A and SL 130-2-1.3 has on Dilloe Run which is also affected by AMD flows outside of Hillman State Park	New station. This station is also now a stream reading for Raccoon Creek Study, SL 130-7
40	Evaluate the water quality at the mouth of this tributary. This will determine the effect of construction in Subwatersheds 1-22, 3-14, 3-16, 3-17 and 3-18	4 monthly readings from February, 1971 to May, 1971

The small water sample was acidified in the field. Analyses performed on the samples from each station included pH (field and laboratory), acidity, alkalinity, iron, sulfate, aluminum and manganese.

Results of Phase I Monitoring: The results of the water quality data for each individual station are presented in the Appendix of this report. Figures 7, 8, 9, and 10 show graphically the Phase I water quality compared to the previous data reported in the Hillman State Park Mine Drainage Survey SL 130-2 dated April 14, 1972. The Consultant's interpretation of the water quality data is summarized on Table 2. The status of construction for each pollution abatement project either under construction or proposed is also shown on Table 2.

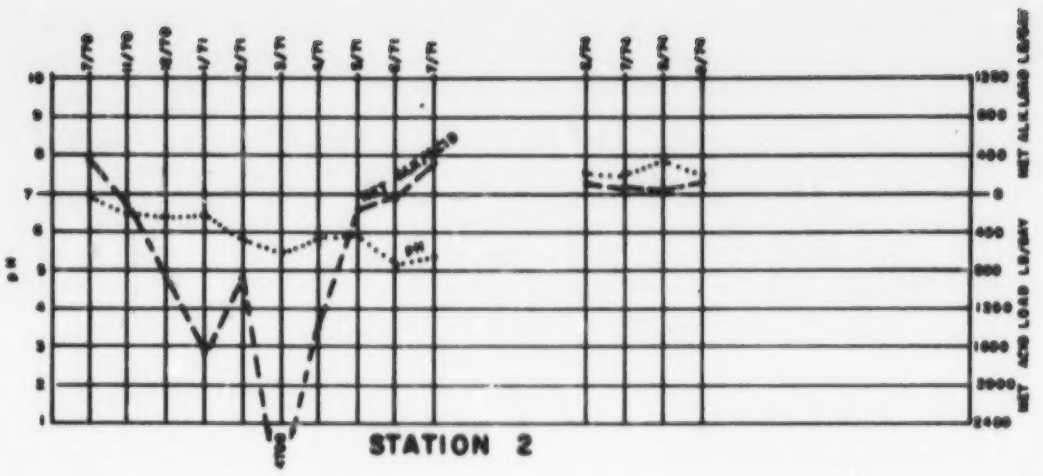
Summary of Pollution Load Data: Comparison of the water quality data graphically shown on Figures 7 through 10 indicates the majority of streams have increased in pH and decreased in acid load. This is basically thought to be the result of construction on the various pollution abatement projects. However, comparison of the data from May, June and July, 1971, to August and September, 1974 indicates the streams in both years, 1971 and 1974, showed an increasing trend in pH and a decrease in net acid load during this period of the year. The converse trend is apparent during the winter months. Therefore, the sampling during the winter months of 1974-1975 will be necessary to complete the analysis of the effect of construction of the abatement project on the water quality of Hillman State Park streams.

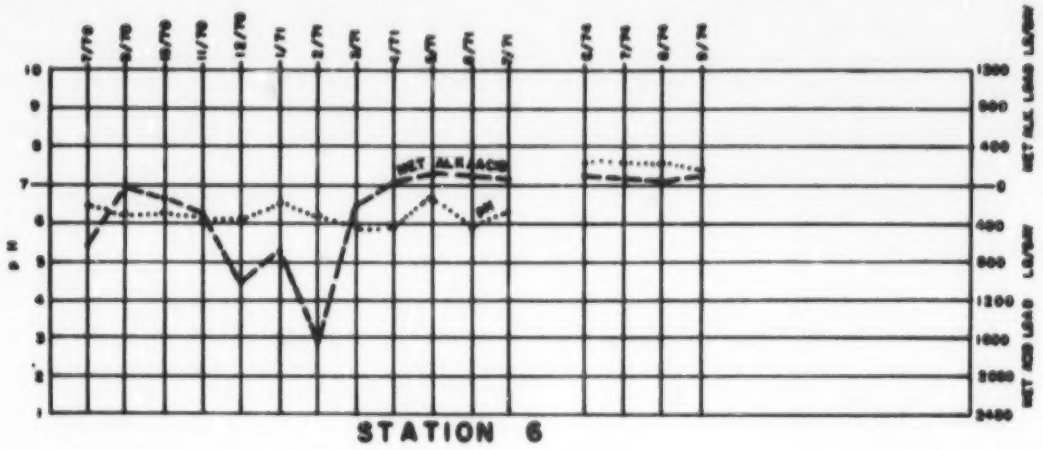
STRIP MINE SPOIL

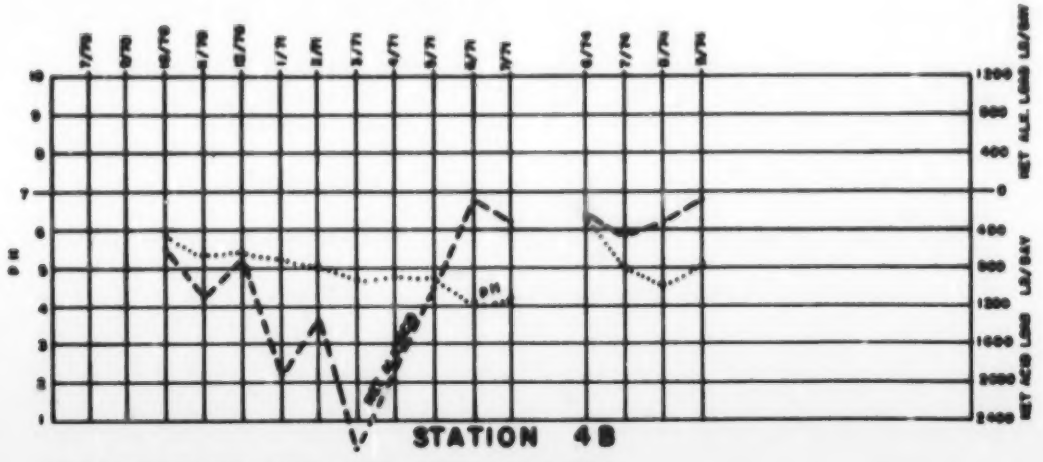
Sample Collection and Laboratory Testing: Sixteen pound bag samples of the strip mine spoil were collected at various locations in the demonstration areas. Each bag sample contained about 15 pounds (6.8 kilograms) of spoil material obtained from a test pit. The depth of the test pits varied, but were approximately 2 feet (.6 meters) in depth. These shallow in depth surface samples were considered to be representative of the non-homogeneous spoil material which would be exposed on the finished grades as based on our review of the previous construction projects in Hillman State Park. In depth subsurface sampling of the spoils was considered economically non-feasible for this project. The following laboratory tests were performed on the samples of the strip mine spoils:

Laboratory pH	All Samples
Mechanical Analysis	Samples 1, 4, 9, 13
Limestone and Fertilizer Requirements	Samples 1, 4, 6, 7, 9, 12, 13, 14, 15
Chemical Analysis and Moisture Retention	Samples 4 and 7

The results of this testing program are reported in the following sections of this report.

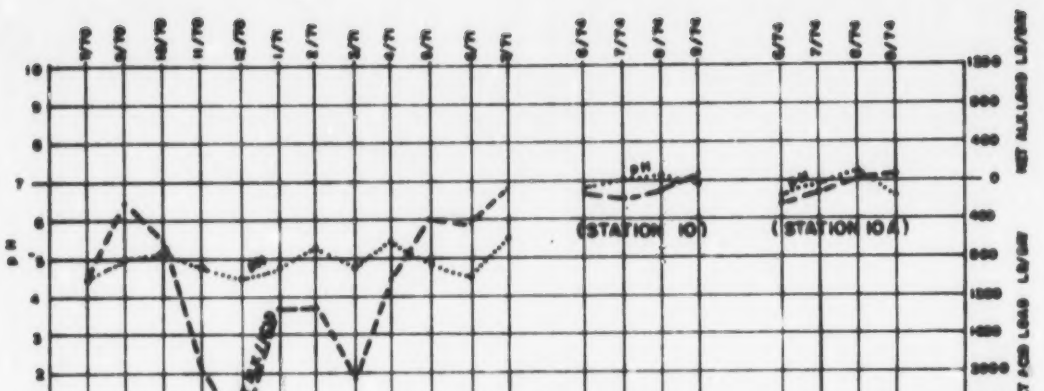




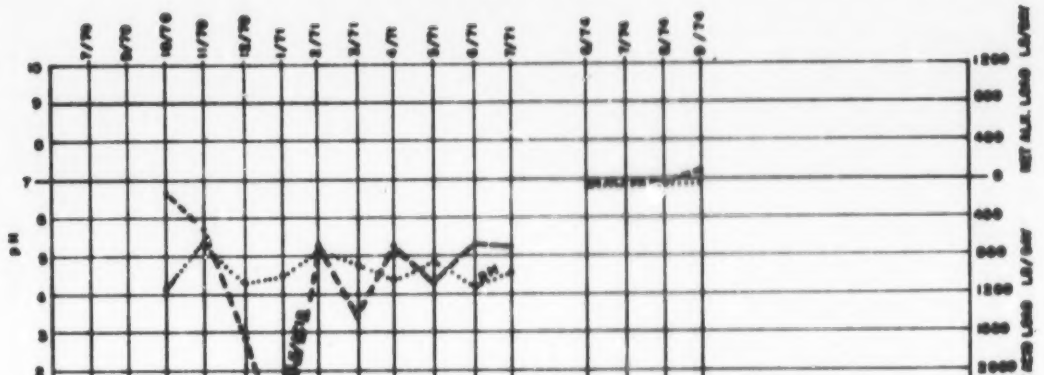


NOTE: TO CONVERT FROM LB/DAY to Kg/Day, MULTIPLY BY 0.4536

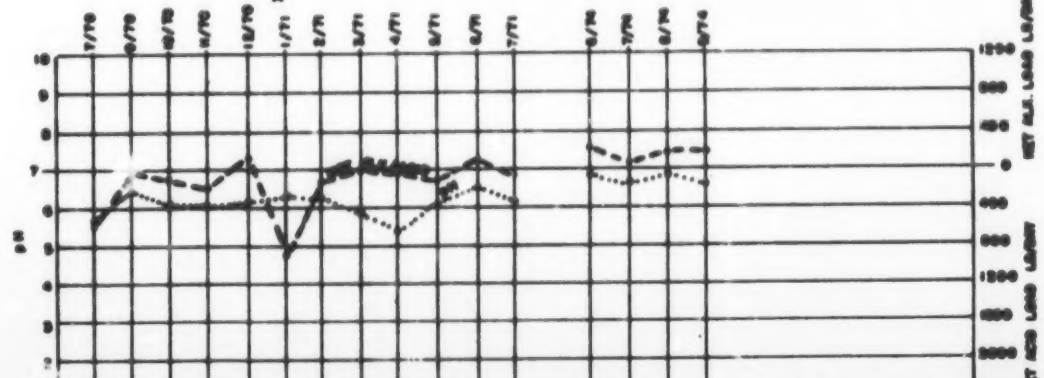
FIGURE 7 WATER QUALITY DATA, STATIONS 2, 4B and 6



STATION 10 & 10A



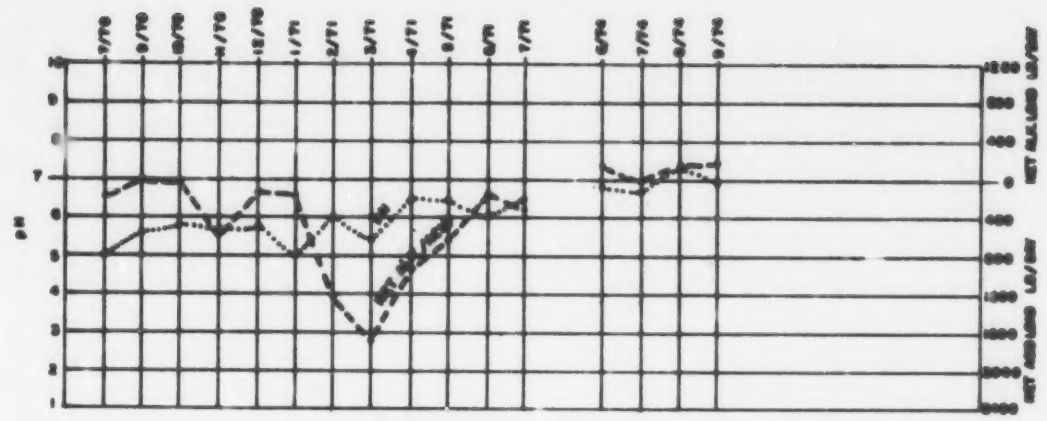
STATION 12



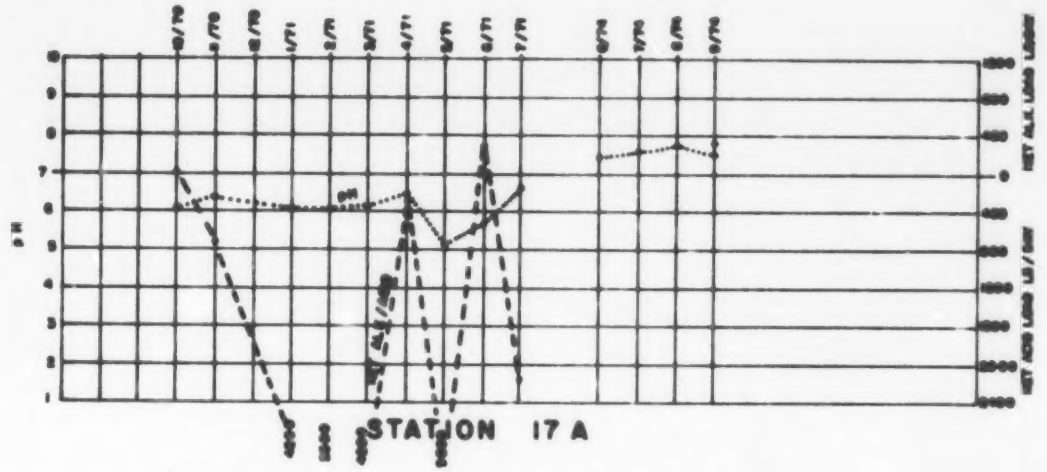
STATION 16

NOTE: TO CONVERT FROM LB/Day TO kg/Day, MULTIPLY BY 0.4536

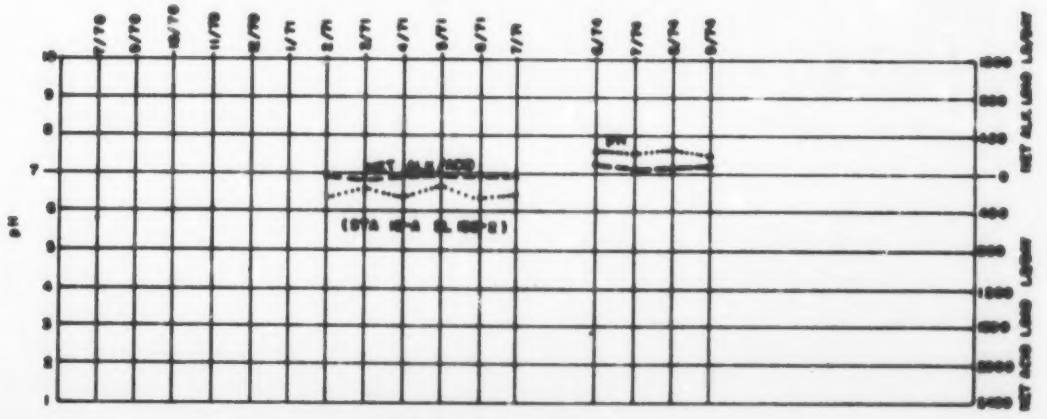
FIGURE 8 WATER QUALITY DATA, STATIONS 10, 10A, 12 and 16



STATION 17



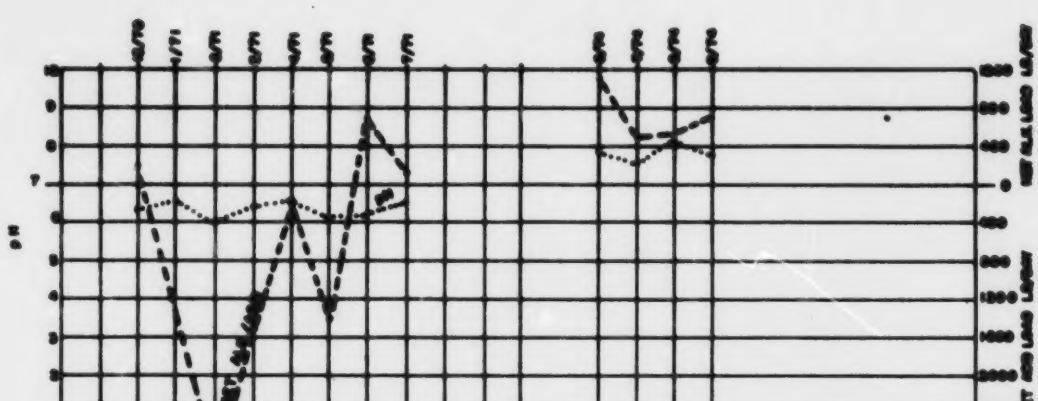
STATION 17 A

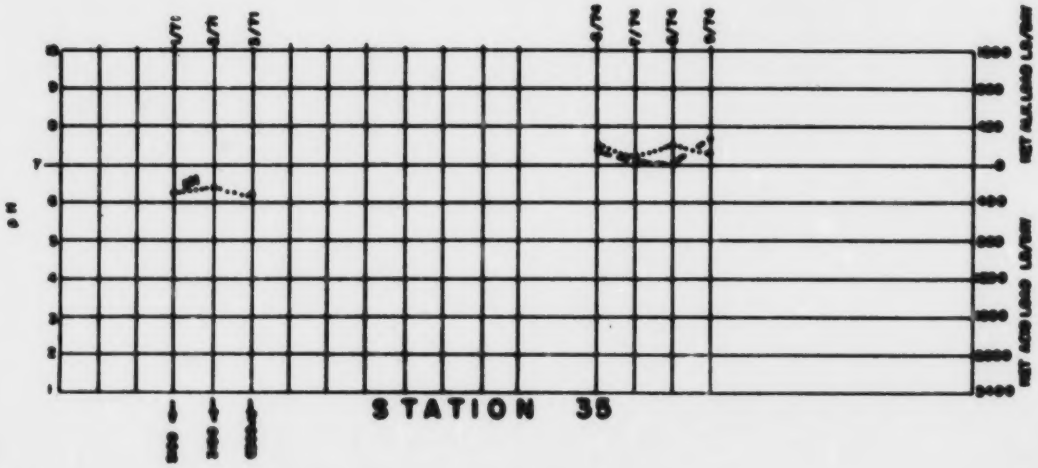


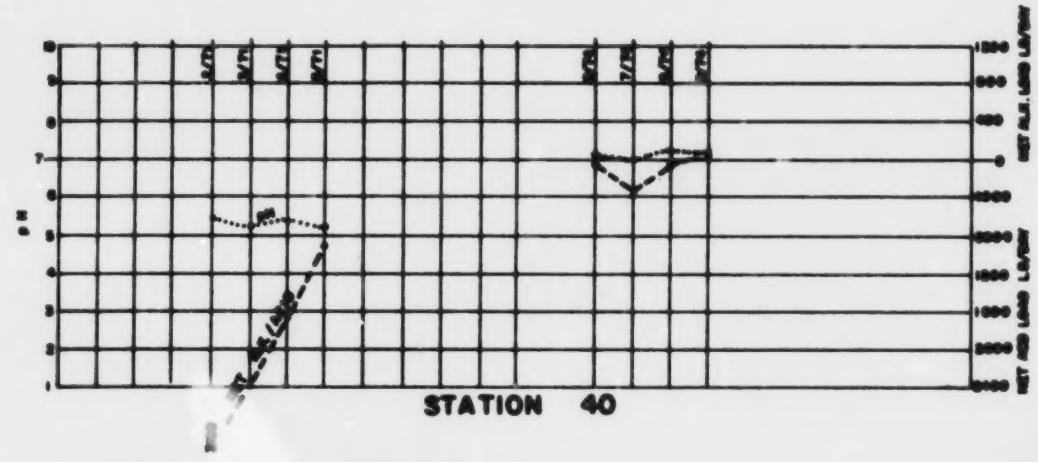
STATION 18A

NOTE: TO CONVERT FROM LB/Day TO Kg/Day , MULTIPLY BY 0.4535

FIGURE 9 WATER QUALITY DATA , STATIONS 17 , 17A , and 18A







NOTE: TO CONVERT FROM LB/DAY TO Kg/Day, MULTIPLY BY 0.4536

FIGURE 10 WATER QUALITY DATA, STATIONS 32, 35 and 40

TABLE 2. PHASE I - WATER QUALITY SUMMARY: JUNE-SEPTEMBER, 1974

STATION NUMBER	STATUS OF CONSTRUCTION AFFECTING SAMPLING STATIONS	WATER QUALITY SUMMARY AND COMPARISON WITH PREVIOUS DATA
2	Project SL 130-2-1.4 Completed	pH now above 7. Stream net alkaline*
4B	Projects SL 130-2-1.1A and SL 130-2-1.3 Completed	pH still below 7. Stream net acid load; however, acid load much less
6	Project SL 130-2-1.3 Completed	pH above 7. Stream net alkaline; similar trend also shown in April-June, 1971, prior to any construction
10	Demonstration Portion Under Design. Project SL 130-2-1.1A Completed. Project SL 130-2-1.3 Under Construction	Average pH, 1971, about 5. Average pH, 1974, about 7. Net acid stream 1971. Lowest acid loads May, July, 1971. Lower acid load in 1974*
10A	Demonstration Portion Under Design. Project SL 130-2-1.1A Completed	New Station
12	Project SL 130-2-1.1A Completed	Average pH in 1971 was 4.6. pH now about 7. Stream acid load much less
16	Demonstration Portion Under Design	pH still below 7; however, slightly higher in 1974. Stream now net alkaline

Table 2 - continued

STATION NUMBER	STATUS OF CONSTRUCTION AFFECTING SAMPLING STATIONS	WATER QUALITY SUMMARY AND COMPARISON WITH PREVIOUS DATA
17	Demonstration Project Under Design	Average pH 1971 was above 5 to less than 7. Average pH 1974 was 6.8 to 7.3. Stream slightly acidic August, 1970 through January, 1971. Highly acidic February, 1971 through June, 1971. Trend in 1974 seems the same.
17A	Demonstration Project Under Design	Average pH 1971 was about 6. pH 1974 slightly above 7.
18A	Demonstration Project Under Design	Average pH 1971 was about 6. pH 1974 slightly above 7
32	Demonstration Project Under Design	Average pH 1971 between 6.0 and 7.0. Stream alkaline in June and July, 1971. Shows same trend in 1974.*
35	Projects SL 130-2-1.1A and SL 130-2-1.3 Completed	pH now above 7. Stream net alkaline.
40	Demonstration Portion Under Design. Project SL 130-2-1.1A Completed. Project SL 130-2-1.3 Under Construction	Average pH 1971 about 5. Average pH 1974 about 7. Net acid stream 1971. Lowest acid loads May, July, 1971. Lower acid in 1974.*

*Based on previous 4 month data; stream was alkaline during this same period of the year, 1971. However, stream was acid from November, 1970 through June, 1971.

Spoil pH: The strip mine spoil materials exposed at or near the surface within the demonstration area are variable and range from pH 2.6 to pH 8.2. The results of the laboratory pH tests are shown on Table 3.

TABLE 3 - SPOIL pH

Sample Number	pH	Sample Number	pH	Sample Number	pH	Sample Number	pH
1	3.9	5	3.5	9	4.3	13	4.4
2	2.6	6	7.7	10	4.2	14	7.8
3	8.1	7	5.4	11	3.1	15	3.7
4	3.0	8	7.7	12	7.4	16	8.0

Mechanical Analysis: Mechanical analyses tests were performed on selected samples to establish the grain size distribution of the strip mine spoils. The grain size analysis does not include any boulder size material as boulders were disgarded during sample collection and those in excess of 1 foot (0.3 meters) will be specified for removal from the upper 1 foot (0.3 meters) of the finished surface during construction. The soil classifications, based on the test results, are shown on Table 4. Although the soil texture classification indicates that the materials are loams and silt loams, the mechanical analysis clearly indicates the presence of 40 to 50 percent gravel size pieces (retained on the No. 10 sieve or greater than 2 millimeters) of rock, shale or coal in the overall sample.

TABLE 4 - MECHANICAL ANALYSIS - SOIL CLASSIFICATION OF SPOILS

Sample Number	Unified Soil Classification Group Symbols[a]	USDA Texture Classification	Percent Passing U. S. Standard Sieve Size #10 (2.0 mm)	#40 (0.4 mm)	#200 (0.7 mm)
1	GM - GC	Loam	59	44	35
4	SM - SC	Loam	50	40	31
9	SM - SC	Loam	58	42	33
13	SM - SC	Silt Loam	59	49	43

[a] Typical Names of group symbols:

GM - Silty Gravels
GC - Clayey Gravels
SM - Silty Sands
SC - Clayey Sands

Limestone and Fertilizer Requirements: Limestone and fertilizer requirement tests were performed by the Pennsylvania State University, College of Agriculture. The sample tests and the crop requirements were selected by the Consultant based on the results of the pH tests and the proposed use of the demonstration area. The two crop categories selected were crown vetch and grass hay. The results of the testing indicated that the limestone application rate varied from zero in the higher pH soils to 10,000 pounds per acre (11,200 kilograms/hectare) in the low pH soils. The limestone requirements for a plow depth of 6 inches (15.2 centimeters) are shown on Table 5.

TABLE 5 - SPOIL LIMESTONE REQUIREMENTS[a]

Sample Number	pH Soil	pH Buffer	Crop	Tons of Limestone per Acre[b]
1	3.9	6.0	Crown Vetch	5
4	3.0	6.0	Grass Hay	5
6	7.7	7.0	Grass Hay	None
7	5.4	6.4	Grass Hay	3
9	4.3	6.0	Grass Hay	5
12	7.4	7.0	Grass Hay	None
13	4.4	6.0	Crown Vetch	5

[a] For a blow depth of 6 inches (15.2 centimeters).

[b] To convert from tons per acre to metric tons per hectare, multiply by 2.24.

Chemical Analysis: Chemical analyses were performed on two samples (Sample Nos. 4 and 7) of the spoil material from the demonstration site. The results of these tests were compared with the analysis performed on spoils from the Stewartstown, West Virginia, site where fly ash treatment was demonstrated on small acre plots by the U. S. Bureau of Mines. The comparison is shown on Table 6. The chemical analysis data on the spoil material prior to the fly ash application at the Stewartstown site was obtained from Mr. John Capp, U. S. Bureau of Mines, Morgantown, West Virginia. The test results indicated that the strip mine spoils from the Hillman Park Demonstration site compare favorably to those strip mine spoils at the Stewartstown, West Virginia, site.

TABLE 6 - CHEMICAL ANALYSIS OF STRIP MINE SPOILS

Constituent	Percent by Weight		
	Sample #4	Sample #7	Stewartstown, W. Va.[a]
Al_2O_3	25	23	15.8
SiO_2	60	58	73.2
Fe_2O_3	7	9	6.6
P_2O_5	1	1	.1
TiO_2	1	1	.4
CaO	NR[b]	1	.3
MgO	NR	2	.3
K_2O	NR	4	2.9
Na_2O	3	NR	.3
SO_3	1	1	NR
CO_2	1	1	NR

[a] Source of Data: L. M. Adams, J. P. Capp and D. W. Gillmore, Bureau of Mines Department of Interior, Morgantown Energy Research Center, Morgantown, West Virginia 26505.
Coal Mine Spoil and Refuse Bank Reclamation with Power Plant Fly Ash, Third Mineral Waste Utilization Symposium, March, 1972.

[b] NR - Not Reported

Moisture Retention: The percentage of water held by different soils varies with texture, structural features, organic matter content, and the like. Four samples of the spoil, together with two fly ash source samples, were sent to the University of West Virginia for determining the capacity of the spoil (mixed at various percentages with fly ash) to retain moisture against given tensions. The results of the moisture retention tests performed on the various combinations of fly ash-strip mine spoil material passing the 1/4 inch wide sieve (6.35 millimeters) are shown on Table 7. The 1/3 bar column and 15 bar column indicate the moisture equivalent or water retained in an air-dried screened sample that is saturated and brought to eqiulibrium on a porous plate at a suction of 1/3 bar and 15 bar, respectively. (1 bar equals 14.5 pounds per square inch or .987 atmospheres). The 1/3 bar retentivity was chosen to insure a better correlation with texture and is considered by some soil scientists as the "field capacity" or percentage of moisture in the soil after drainage has ceased and after capillary adjustments have taken place. Because the 15 bar retentivity is considered by some soil scientists as the "wilting point" or the maximum percentage of moisture possible for plants to withdraw, it was chosen as the other parameter. The column which represents the difference between the 1/3 bar and the 15 bar is the measure used to illustrate the percentage of water retained in a soil between the field capacity and the wilting point and is customarily referred to by some soil scientists as the amount of plant available water or the range of available water.

These test results indicate that the moisture retention of three of the four strip mine spoils at 1/3 bar can be increased with the addition of a minimum of 20% fly ash. The test results also indicate there is a difference in the moisture retention characteristics of the fly ash. The difference is due to the variations in the particle size distribution of the fly ash.

The results of the moisture retention tests at 15 bars pressure indicate that less moisture is retained in the strip mine spoils treated with fly ash as compared to the non-treated strip mine spoil. Therefore, the fly ash treated strip mine spoil can release more moisture than untreated strip mine spoil. The moisture content at 15 bars is highly correlated with soil texture and therefore the addition of fly ash to the strip mine spoils indicated a resulting textural change from a spoil with a heavy texture (more clay size particles) to a spoil which has a coarse texture (more silt and sand size particles).

TABLE 7 - FLY ASH - SPOIL MOISTURE RETENTION TEST RESULTS

Strip Mine Spoil No.	Percent of Fly Ash	Percent Moisture Retention: Fort Martin Fly Ash 1/3 Bar[a]	15 Bar	Δ[b]	Elrama Fly Ash 1/3 Bar	15 Bar	Δ
4	0	21.95	11.61	10.34	21.95	11.61	10.34
4	20	20.98	9.36	11.35	19.92	9.72	10.20
4	30	21.61	8.66	12.95	20.65	8.71	11.94
4	40	23.54	7.81	15.73	21.10	7.93	13.17
7	0	15.49	7.82	7.67	15.49	7.82	7.67
7	20	17.74	6.85	10.89	17.92	6.57	11.35
7	30	19.88	6.20	13.68	18.91	6.04	12.87
7	40	19.37	5.80	13.57	21.31	5.40	15.91
13	0	16.91	9.25	7.66	16.91	9.25	7.66
13	20	18.18	7.91	10.27	18.85	7.76	11.09
13	30	19.95	7.24	12.71	19.35	7.16	12.19
13	40	22.53	6.58	15.95	21.11	6.55	14.56
15	0	16.27	7.54	8.73	16.27	7.54	8.73
15	20	19.84	6.66	13.18	17.79	6.60	11.19
15	30	20.68	5.97	14.71	18.17	5.96	12.21
15	40	20.88	5.62	15.26	19.80	5.73	14.07
Fly Ash	100	36.78	2.92	33.86	25.44	3.57	21.87

[a] Bar equals 14.5 pounds per square inch (.987 atmospheres)

[b] Δ equals the difference in percent moisture retained between 1/3 and 15 Bar

TABLE 8 - CHEMICAL ANALYSIS OF FLY ASH SAMPLES

Constituents	Sample Nos. 1	2	3	4	5	6	7
Sulfur Trioxide (SO_3)	0.2	0.2	0.2	0.1	0.8	0.8	1
Carbon Dioxide (CO_2)							1
Phosphorus Pentoxide (P_2O_5)		0.4	0.4	0.4	0.3	0.3	1
Silica (SiO_2)		51.7	51.6	51.0	51.0	52.6	51
Potassium Oxide (K_2O)		2.3	2.3	2.5	0.3	0.3	2
Iron Oxide (Fe_2O_3)		11.7	13.7	15.7	12.4	12.0	16
Aluminum Oxide (AL_2O_3)	28.4	26.5	26.4	26.5	31.1	31.4	26
Calcium Oxide (CaO)	5.6	3.5	2.7	1.4	1.9	2.0	--
Magnesium Oxide (MgO)	0.9	1.0	0.9	0.8	0.7	0.5	1
Sodium Oxide (Na_2O)	0.7	0.7	0.6	0.3	0.5	1.1	--
Ignition Loss @ 900°C	4.9	2.6	2.0	2.7	5.0	11.0	4
Loss @ 150°C	0.1%	0.2%	0.2%	0.1%	-	-	--
pH of 50% Slurry	10.2	9.7	10.2	10.5	10.7	10.1	--

Sample 1: West Penn Power Company, Mitchell Power Station, No. 33 Boiler Operation at 296 Megawatts.

Sample 2: Monongahela Power Company, Fort Martin Power Station, No. 1 Output, 515 Megawatts.

Sample 3: Allegheny Power Service Corporation, Hatfield Power Station, No. 2 Boiler, 485 Megawatts.

Sample 4: Allegheny Power Service Corporation, Albright Power Station, No. 3 Boiler, 120 Megawatts

Sample 5: Duquesne Light Company, Elrama Station, Composite of Minus 60 Mesh Samples Over 2 to 4 Week Period (1969) When As Fired Coal Could Be Well Defined.

Sample 6: Duquesne Light Company, Phillips Station, Composite of Minus 60 Mesh Samples Over a 2 to 4 Week Period (1969) When As Fired Coal Could Be Well Defined.

Sample 7: Beaver Valley Plant, Arco/Polymers, Inc.

FLY ASH

Availability: Seven coal fired electric generation stations are located within a 75 mile radius of the demonstration site. The locations of these stations are shown on Figure 11. Representatives of the Monongahela Power Company, Allegheny Power Service Corporation, and Duquesne Light Company and Arco-Polymer, Inc. were contacted as to the availability of the pulverized fuel fly ash. It was the general consensus of all representatives contacted that sufficient fly ash was available for the demonstration project. Advance shipment notices and tonnage requirement, however, would have to be projected in order to facilitate delivery.

Stockpiling of fly ash at the demonstration area will probably be required to provide the quantity of fly ash necessary for complete application within a short period of time. The amount of stockpiling can be minimized if the contractor treats individual work areas as the grading is completed. Several areas will be designated as possible fly ash storage areas on the construction contract drawings. It will be the responsibility of the Contractor to determine fly ash tonnage delivery rates. The Contractor's responsibility will also include all liaison with the Power Utility Companies supplying the fly ash.

Chemical Analysis of Fly Ash: The chemical analyses of fly ash shown on Table 8 were provided by the local electric utility companies and a private power generation station. The results of the analyses indicate that the fly ash from the various sources are similar in composition and pH.

Fly Ash Neutralization Capacity: Fly ash, although it is not extremely variable in chemical composition, does vary in its capacity to neutralize acidic strip mine spoils. Therefore, one of the criteria in the economic selection of a fly ash source will be the capacity of the fly ash to neutralize the strip mine spoils and the subsequent application rate amount required. Fly ash from 6 local power generation stations was tested to determine the neutralization capacity of each of the fly ash samples. Neutralization capacity, as used in this report is defined as the ability of fly ash to neutralize acidic strip mine spoils as expressed in milliequivalents of standardized acid required to lower the pH of 1 gram of fly ash to pH 7. The neutralization capacity of the fly ash sample was determined by the procedure of titrating a solution of 2 grams of fly ash and 50 milliliters of distilled water to a pH of 5.8 with .02 $\underline{N}$ H_2SO_4 daily for a total period of seven days. The neutralization capacity was calculated from the volume of acid consumed by each sample over all seven titrations, and expressed as milliequivalent of H_3O^+ per 100 grams fly ash. The results of the tests are shown on Table 9.

Transportation Cost Analysis and Permits: Transportation costs from the various power stations were developed using data supplied by various trucking companies and the utility companies. The distance from the demonstration site to the various utilities is shown on Figure 11. The estimated transportation costs from the various fly ash sources is shown on Table 10.

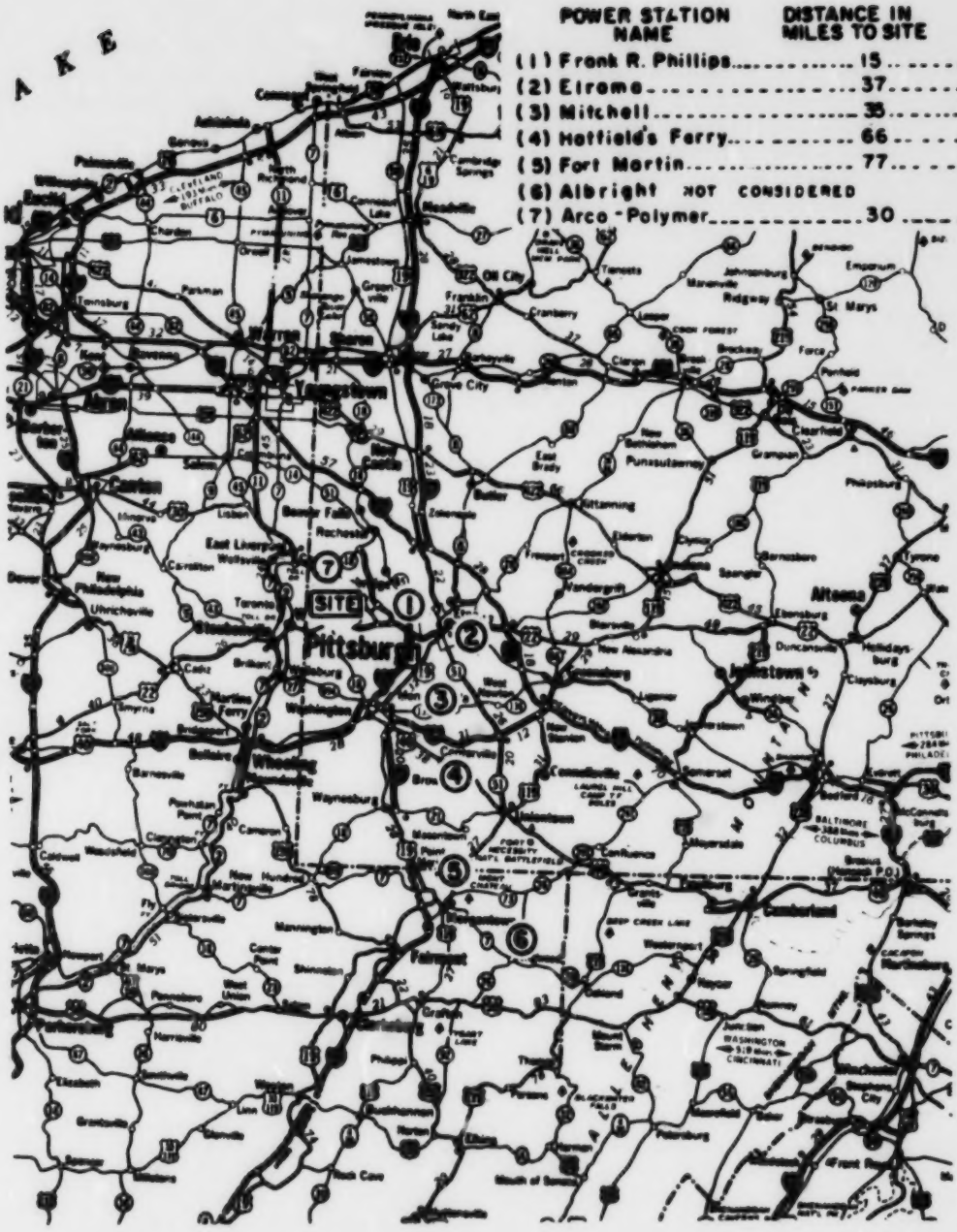

POWER STATION NAME
DISTANCE IN MILES TO SITE
IN Km.
(1) Frank R. Phillips ..... 15 ..... 24.1
(2) Elrama ..... 37 ..... 59.5
(3) Mitchell ..... 35 ..... 56.3
(4) Hatfield's Ferry ..... 66 ..... 106.2
(5) Fort Martin ..... 77 ..... 123.9
(6) Albright NOT CONSIDERED
(7) Arco - Polymer ..... 30 ..... 48.0
SITE
Pittsburgh
Youngstown
Altoona
Cumberland
Fairmont
Wheeling
Morgantown
Uniontown
Washington
Greensburg
Johnstown
Clearfield
Indiana
Kittanning
Punxsutawney
Oil City
Franklin
Warren
Meadville
Sharon
Ashtabula
Conneaut
Erie
Jamestown
Olean
Bradford
Kane
Ridgway
St Marys
Emporium
Lock Haven
Huntingdon
Bedford
Somerset
Connellsville
Uniontown
Waynesburg
Washington
Wheeling
Steubenville
Weirton
Cambridge
Zanesville
Marietta
Parkersburg
Clarksburg
Fairmont
Morgantown
Uniontown
Greensburg
Johnstown
Altoona
Harrisburg
Lancaster
Reading
Allentown
Bethlehem
Easton
Scranton
Wilkes-Barre
Hazleton
Pottsville
Williamsport
Lock Haven
Sunbury
Lewistown
Carlisle
Gettysburg
Chambersburg
Hagerstown
Frederick
Cumberland
Keyser
Romney
Petersburg
Moorefield
Elkins
Buckhannon
Weston
Glenville
Spencer
Ripley
Point Pleasant
Huntington
Ashland
Ironton
Portsmouth
Chillicothe
Athens
Logan
Gallipolis
Pomeroy
Middleport

TABLE 9 - FLY ASH NEUTRALIZATION CAPACITY[a]

Fly Ash Source	Initial pH	Neutralization Capacity[b]	Equivalent Tons Per Acre[c]
Mitchell	10.6	45	1
Hatfield Ferry	9.1	21	2
Fort Martin	9.1	19	2
Arco-Polymer	9.0	6	8
Elrama	9.7	4	11
Phillips	9.0	3	15
Albright	7.5	1	--

[a] Symposium of Fly Ash Utilization, 2nd., Pittsburgh, 1970 (U. S. Bureau of Mines, Information Circular 8488, Page 310)

[b] Expressed as milliquivalents of H_3O^+ per 100 grams fly ash.

[c] To convert tons per acre to metric tons per hectare, multiply by 2.2416.

TABLE 10 - FLY ASH TRANSPORTATION COST ESTIMATE

Power Station Source	Approximate Distance Miles	(Kilometers)	Transportation Costs[a] Tons	Total Cost[b] Per Ton
Phillips	15	(24)	$1.48	$1.73
Arco-Polymer	30	(48)	$2.53	$2.78
Mitchell	35	(56)	$2.88	$3.13
Elrama	37	(60)	$3.02	$3.27
Hatfield-Ferry	66	(106)	$5.05	$5.30
Fort Martin	77	(124)	$5.82	$6.07
Albright	Not Considered Because of Low Neutralization Capacity of the Fly Ash			

[a] Based on $0.50 per ton (.9 metric ton) for the first mile (1.6 kilometers) and $0.07 for each additional mile (1.6 kilometers)

[b] Assumes a $0.25 per ton (.9 metric ton) charge which may be requested by Utility Company

NOTE: To convert cost/ton to cost/metric ton, multiply by 0.9072.

The transportation costs were based on:

Dump trucks using tarpaulin for dust prevention.

Hauling rates based on ton/mileage (one-way distance)

Transportation of the fly ash is governed under the Commonwealth of Pennsylvania Public Utility Commission (PUC) and Federal Government Interstate Commerce Commission (ICC). PUC regulates shipment within the Commonwealth of Pennsylvania whereas the ICC regulates shipment across state lines. Release of the fly ash of certain utility companies may require permission from the local governing body of Hanover Township Commissioners for utilization of fly ash on their lands. The Chairman of the Township Commissioners expressed his verbal approval at this time and written approval by the Board of Commissioners is anticipated. Compliance with all local, state and federal regulations regarding transportation and utilization of fly ash will be included in the "General Conditions" for construction.

Additional Sources: One additional source of fly ash from a private power generation station (Arco-Polymer, Inc. - Kobuta, Pennsylvania) was investigated for suitability of use in the demonstration area. The chemical analysis performed on samples from this source indicated that the chemical composition was within the limits of the standard constituents; however, this fly ash was not considered for the demonstration project due to the low neutralization capacity of the fly ash mixture.

STRIP MINE SPOIL - FLY ASH MIXTURES

Purpose: Samples of strip mine spoils and fly ash were mixed in various percentages in the laboratory to determine the tonnage of fly ash which will be necessary to raise the pH of the strip mine spoil to about 7. Several strip mine spoil samples were chosen to reflect the variations in the pH of the spoils at the site. The spoils were mixed in various percentages with samples of fly ash from the Fort Martin and Mitchell Power Stations. The percentages by weight of fly ash were then converted to tons/acre using the conversion factor of 6 inches (15.2 centimeters) of soil (plow layer) per acre (0.4 hectare) equals 1000 tons (907 metric tons).

Spoil - Fly Ash Titration Procedure: Spoil samples were prepared for testing by grinding until 100% of the sample passed through a No. 10 sieve (2 millimeters). Ten grams of spoils were mixed with 10 grams of distilled water, thoroughly stirred, then allowed to equilibrate overnight. The resultant pH of the equilibrated spoil-water mixture was then measured.

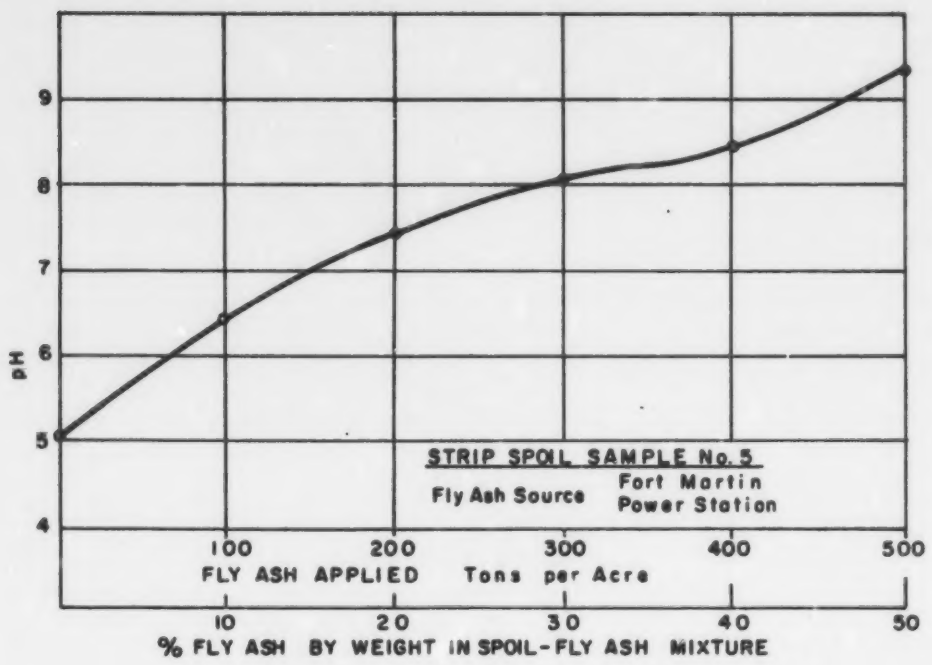
Equilibration of the sample is achieved when a constant pH is reached following mixture. Time for equilibration varied, but usually required 24 hours for the spoils-distilled water mixtures, and about 48 hours for spoil-fly ash distilled water mixtures.

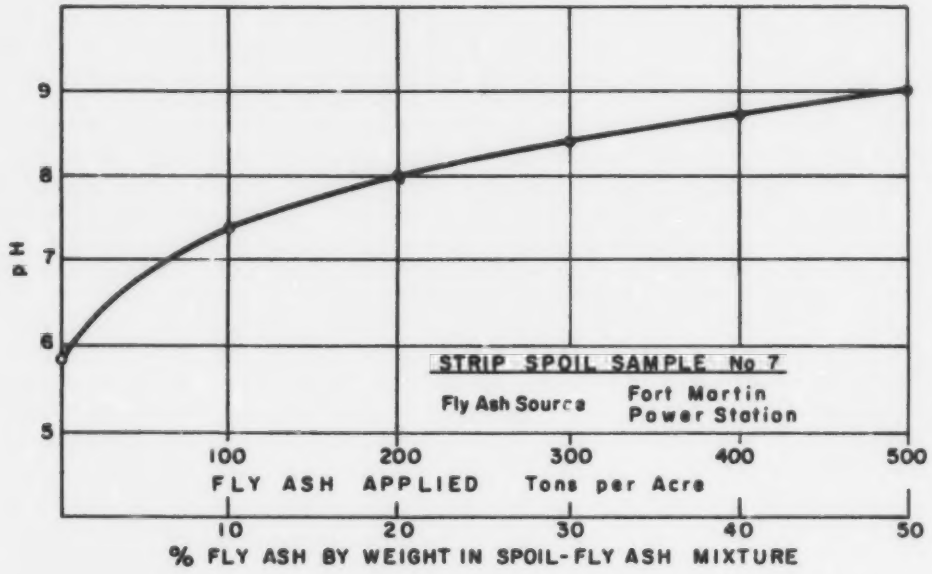
The titration procedure consisted of mixing equal weights of fly ash and distilled water to each equilibrated strip mine spoil-distilled water mixture to yield 10, 20, 30, 40 and 50% by weight mixtures of fly ash-strip mine spoil materials. The fly ash-spoil mixtures were then allowed to equilibrate for 72 hours. pH measurements were taken at 24 hour intervals to check for equilibration. A graph was then prepared by plotting pH against percent fly ash by weight. Figures 12 through 14 show the graphs which were obtained. The data shown on the graphs represent the percent of fly ash by weight needed to raise the spoil-fly ash mixture to a pH of 7.0.

Samples of the demonstration area spoils and fly ash from the selected power stations were also sent to the U. S. Bureau of Mines at the Morgantown Energy Research Center. Four equivalent tests were performed under the direction of Mr. John P. Capp. Figures 15 through 16 show the results of these tests. The graphs show the amount of fly ash applied in tons per acre and in percent by weight.

Discussion of Results: A linear relationship was found between the pH of the various spoils at the demonstration site and the required fly ash with a constant neutralization capacity needed to raise the spoil-fly ash mixture pH to about 7.0. Figure 17 shows the relationship for 5 spoil samples with different pH's using fly ash from the Mitchell Power Station as its equivalent. Mitchell fly ash was chosen as the baseline since it has the highest neutralization potential of the available fly ash indicated on Table 9.

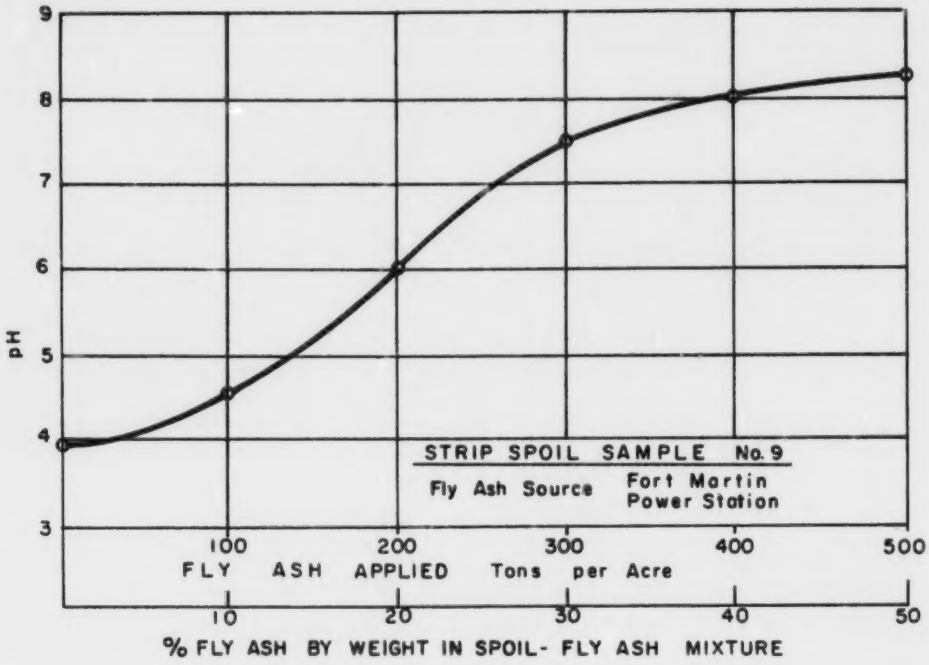
Furthermore, equivalent applications of fly ash with less neutralization capability than the Mitchell fly ash were found to be the inverse of the ratio of the neutralization capacity of the other fly ash samples to the neutralization capacity of the Mitchell fly ash. Thus, fly ash from the Fort Martin Power Station, which has approximately one-half of the neutralization capability of the Mitchell fly ash (21 to 45, see Table 9), would require about twice the tonnage per acre to achieve the same neutralization as the Mitchell fly ash. For example, reference to Figure 17 shows that 125 tons/acre (280 metric tons/hectare) of Mitchell fly ash will be required to raise the pH of spoils from pH 4.0 to 7.0. If Fort Martin fly ash were chosen as a substitute for Mitchell fly ash, the application rate must be doubled to 250 tons/acre (560 metric tons/hectare) because the neutralization capacity of Fort Martin fly ash is one-half that of the Mitchell fly ash. Moreover, eleven times the amount of Elrama fly ash or 1,375 tons/acre (3,082 metric tons/hectare) would be required for the same effect.

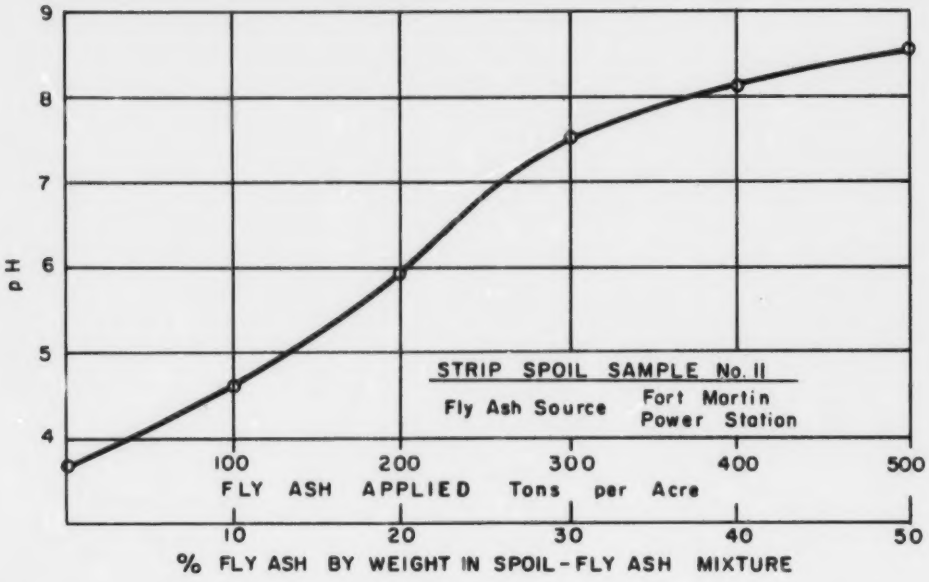




NOTE: TO CONVERT TONS per ACRE TO METRIC TONS per HECTARE, MULTIPLY BY 2.2416

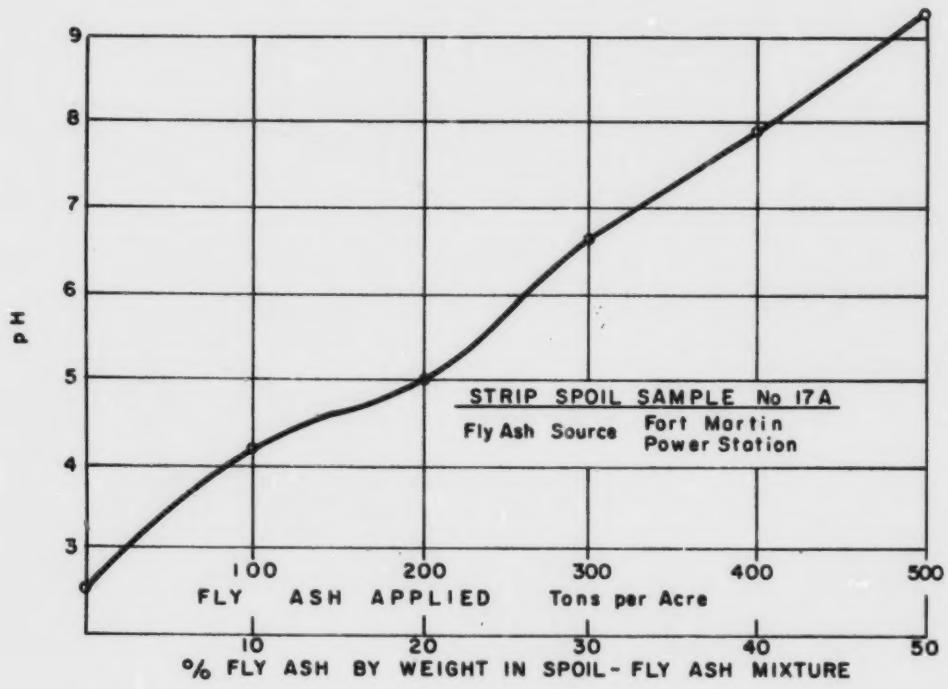
FIGURE 12 pH OF VARIOUS SPOIL-FLY ASH MIXTURES





NOTE : TO CONVERT TONS per ACRE TO METRIC TONS per HECTARE , MULTIPLY by 2.2418

FIGURE 13 pH OF VARIOUS SPOIL - FLY ASH MIXTURES



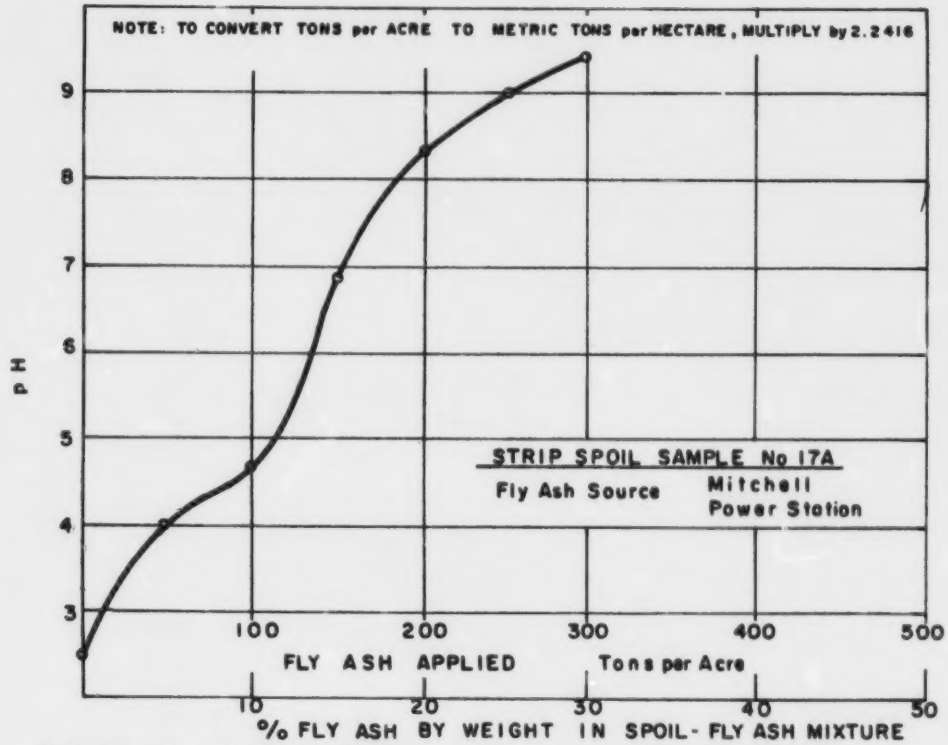


FIGURE 14 pH OF VARIOUS SPOIL-FLY ASH MIXTURES

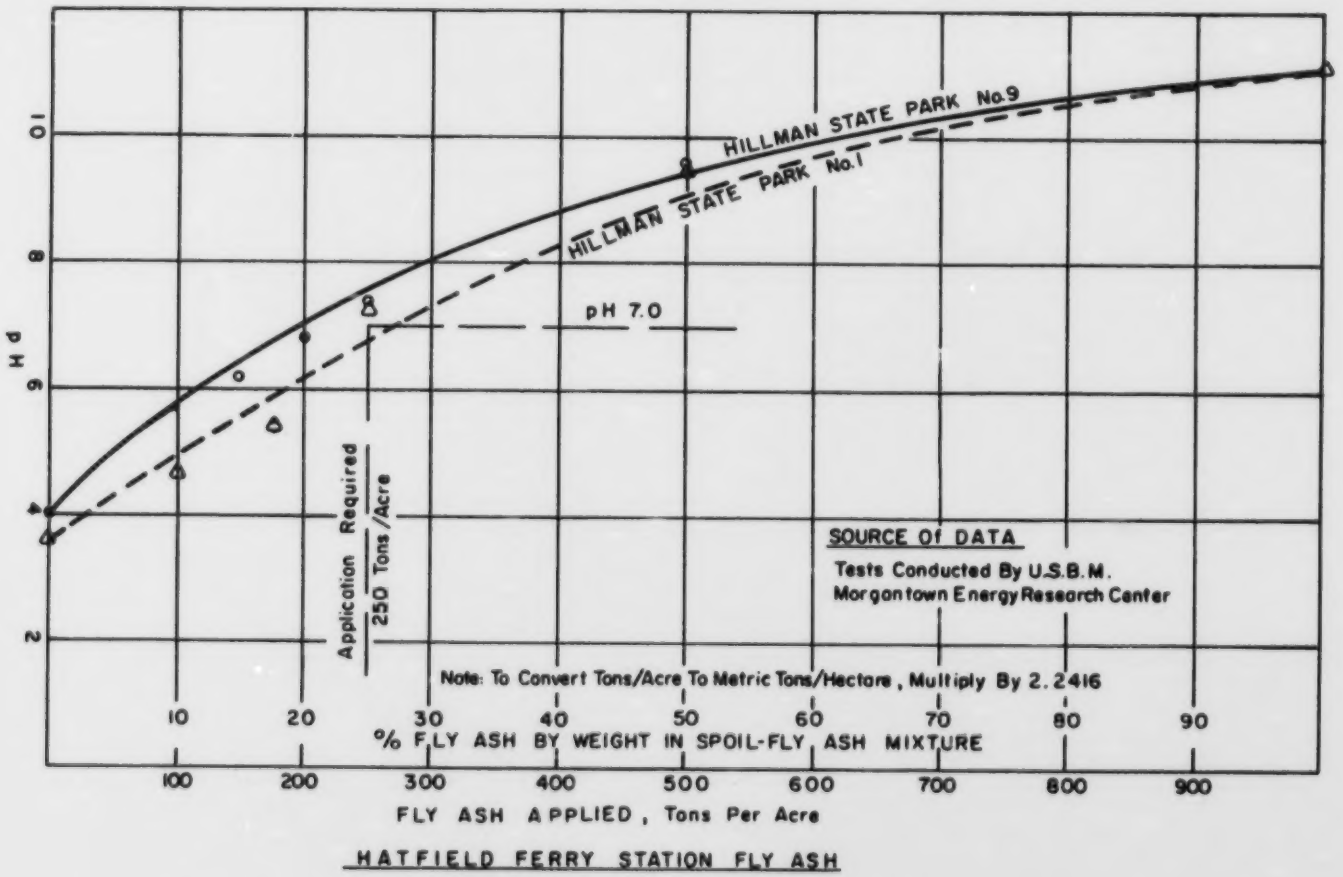


FIGURE 15 pH OF VARIOUS SPOIL-FLY ASH MIXTURES

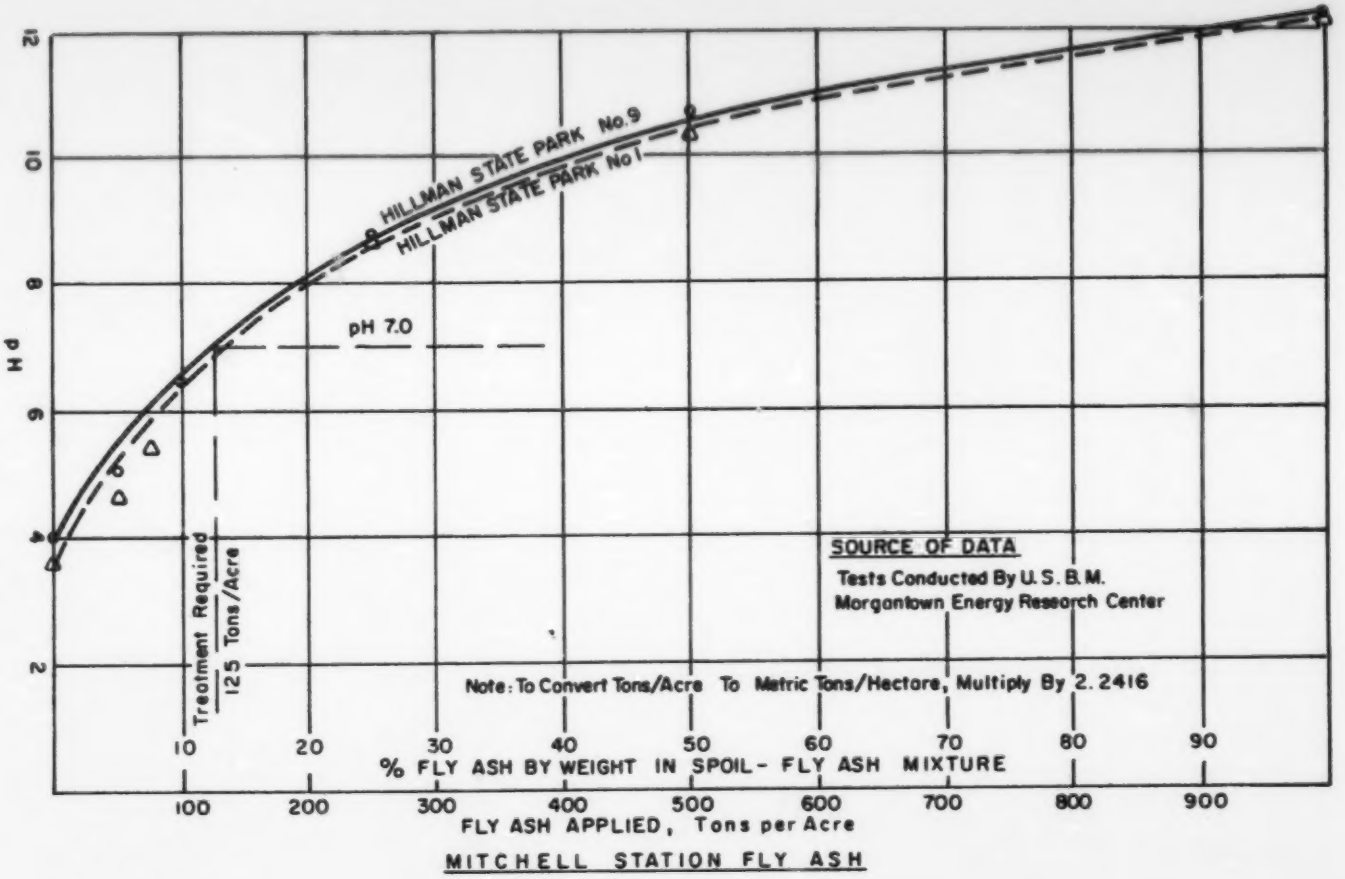
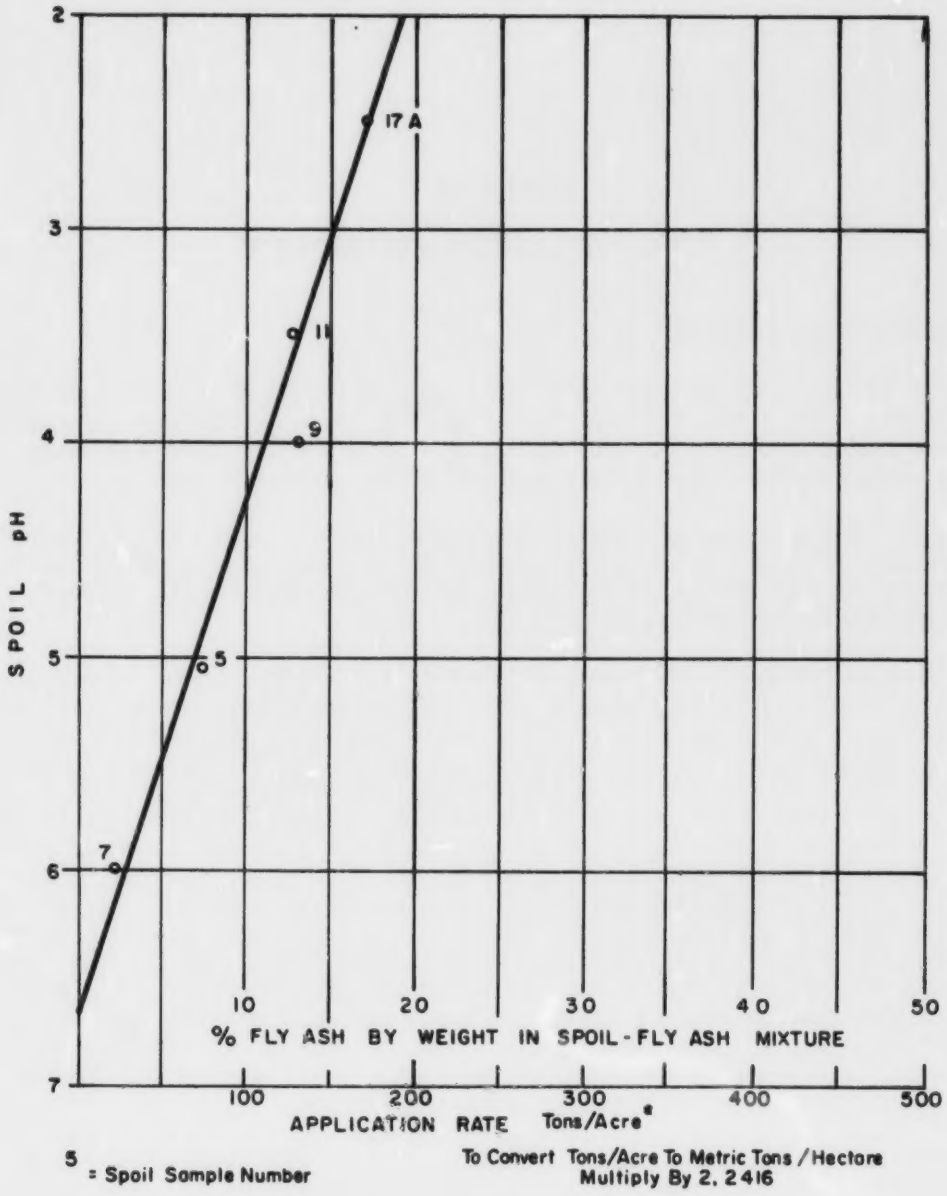


FIGURE 16 pH OF VARIOUS SPOIL - FLY ASH MIXTURES



FLY ASH REQUIREMENTS TO RAISE SPOIL pH TO 7 USING FLY ASH WITH AN EQUIVALENT NEUTRALIZATION CAPACITY (Mitchell Power Station)

FIGURE 17 FLY ASH APPLICATION RATE

SECTION VI

FLY ASH APPLICATION CONSIDERATIONS

NEUTRALIZATION VARIABLES

The fly ash application rate determination must consider the variability of the pH of the strip mine spoils throughout the demonstration area and the neutralization capacity of the fly ash source while also including the economic factors that affect each of these considerations.

Spoil pH: Because the acidity of the spoil material that will be exposed at finished surface cannot be determined until final grades are achieved, the amount of fly ash required from a particular source must be determined by one of the following methods:

Variable method - this method involves the establishment of a grid system of the project area which could separate work areas into acre plots or other suitable subdivisions. From each subdivision the average pH of the spoils would be analyzed to determine the amount of fly ash required from a particular source. This method, however, involves field layout and testing which would increase the cost of these respective services. An additional increase in the cost could also be expected because the contractor will not know prior to bidding and until finished grades are established the exact amount of fly ash required or work incidental thereto for a particular area. A suitable method or subdivision which could be effectively controlled in the demonstration area would be to divide the project into work areas which could be further separated into major cut and fill areas. Utilization of a variable method, however, minimizes the over or under treatment of the finished work areas with fly ash and could result in a more uniform growth of vegetation.

Uniform application rate - this method of establishing the fly ash application rate requires a statistical analysis of the soil pH throughout the project demonstration area and the determination of an average pH to be utilized for determining the application rate of fly ash. This method can result in over treatment or under treatment of certain areas within the entire project, thereby affecting the growth of vegetation. This method, however, would result in a predetermined cost estimate and eliminates additional field work, sampling and testing, and would demonstrate whether or not a fixed rate of application would be sufficient to produce the desired vegetative cover utilizing fly ash in lieu of lime. Because economics is always of prime consideration, a fixed cost estimate may be more desirable.

Fly Ash Neutralization Capacity: Because of the variances of the neutralization power of the fly ash sources, the application rate required to be applied with the strip mine spoils will vary with the selected fly ash source. The source with the greatest neutralization capacity should be considered if the distance of haulage is not economically excessive and provided that no other source with less neutralization capacity is more economically available in larger quantities, thereby enhancing the moisture retention characteristics.

ECONOMIC VARIABLES

The economics of the transportation costs for fly ash are composed of the distance of the source of the fly ash from the project area and the neutralization capacity of the fly ash. A source of fly ash close to a project area may not always be economical if that source of fly ash has a low neutralization capacity because a higher tonnage of fly ash would be required to neutralize the strip mine spoils. Transportation rates are based on ton/miles hauled and the total costs would be reflected by any increased tonnage required. Additional costs would also be incurred on a project if the owner of the fly ash established a minimal sale dollar for the fly ash to recover some of his incurred costs.

METHODS OF APPLICATION

Equipment: The types of equipment utilized will be the choice of the contractor; but, specifications should require that the fly ash be uniformly distributed and thoroughly mixed with the upper 6 inches (15 centimeters) of surface spoil, in a suitable manner, whereby the finished surface will not contain deep furrows.

SECTION VII

PROPOSED PLANS FOR PROJECT IMPLEMENTATION

CONSTRUCTION PLAN

Construction plans, including working drawings and specifications for the demonstration area, are being developed under Engineering Contract SL 130-2-1 with the Commonwealth of Pennsylvania. The construction will be performed under Contract SL 130-2-1.1B with the Commonwealth of Pennsylvania. The reclamation is designed to provide drainage from twelve small subwatersheds (340 acres) or (138 hectares) which comprise the demonstration area. The two major design criteria used are:

Eliminate the depressions within the subwatersheds and provide positive runoff and drainage by regrading strip mine spoils.

Balance the cuts and fills to eliminate the need for disposal of excess material.

The basic design criteria in the demonstration area are the same criteria used throughout the other Hillman State Park abatement projects. The general location of the proposed drainage from the subwatershed work area is shown on Figure 6. An example of the cut and fill application that will be used in the reclamation work is shown on Figure 18. An estimated 1,200,000 cubic yards (917,520 cubic meters) of spoil material will be moved during the regrading operations over an area of approximately 180 acres (72.8 hectares). Cuts vary from a few feet (or meters) to an estimated maximum of 55 feet (17 meters), whereas fills up to 35 feet (11 meters) in height occur.

SEQUENCE OF CONSTRUCTION

The sequence of work within the demonstration area which will be established by the Contractor will include the following items of construction:

Clearing and Grubbing

Earthwork and Drainage Facilities

Erosion and Sedimentation Measures

Fly Ash Application

Soil Treatment and Seeding

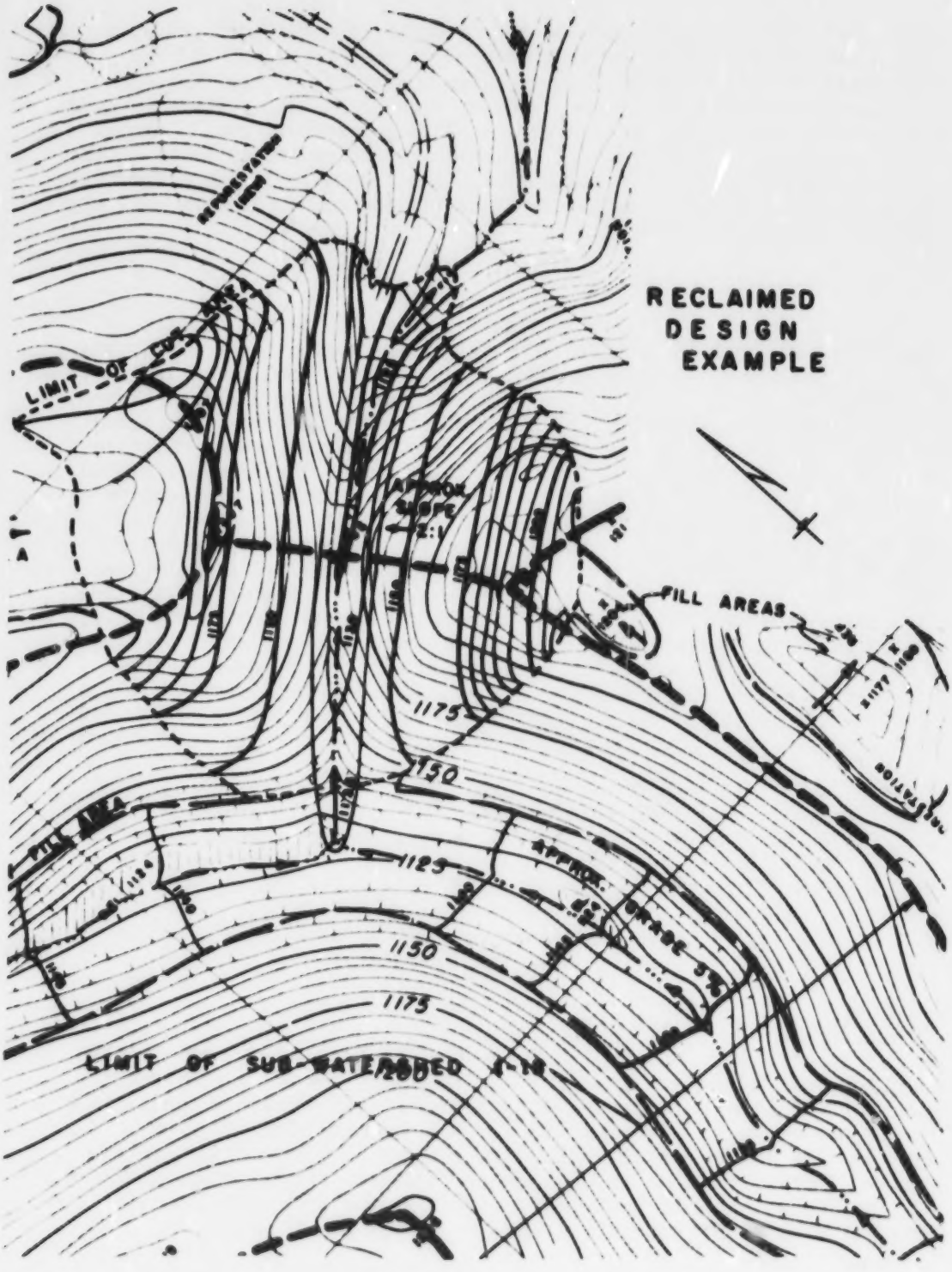


FIGURE 18 RECLAMATION DESIGN EXAMPLE

After each separate work area has been brought to a finished grade, a semi-final inspection should be conducted by the Consultant and the Department of Environmental Resources for conformity of the finished grade and proposed items of construction with the design. Finished grade requirements shall include the removal of rocks greater than 12 inches (30.5 centimeters) from the top 6 inch (15.2 centimeter) layer of spoils and the removal of any high concentrations of boney coal. Upon approval of the finished grades, the placement of fly ash and subsequent soil treatment and seeding can commence.

FLY ASH APPLICATION METHODS AND RATE

Recommended Method - Variable Application Rate: It is the opinion of the Consultant that in order to demonstrate the capabilities of fly ash as a soil modifier, a variable rate of application should be utilized to minimize the over or under treatment of the finished work areas. The construction plans developed for the demonstration are shown as separate work areas which are further subdivided into major cut areas, fill areas, and grading areas beyond major cut and fill areas. These major cut and fill subdivisions will serve as the limits of the various application rates. The rate of fly ash application will be determined when final grade is reached in these areas. The application rate will be based upon an average pH of the spoils in each area. A minimum application rate of 50 tons (45 metric tons) of fly ash per acre should be utilized to increase the moisture retention capabilities of the spoils regardless of the pH of the untreated finished grades where fly ash application is specified. Areas where fly ash application will not be used in the demonstration area are generally within proposed channel sections where flows are concentrated and in areas of grading beyond the major cut and fill areas where the existing and proposed grades are relatively steep.

Alternative Method - Uniform Application Rate: A uniform rate of application could be established prior to letting of the Construction Contract. The average pH of the strip mine spoils in the demonstration area is 4.0. This is based on the results of the 16 tests performed on the spoil materials. Using an average pH of 4.0 for the entire project a uniform rate of fly ash per acre could be specified. This would demonstrate whether a pre-determined rate application is an effective method in neutralizing acidic spoils of varying pH.

Application Rate Determination: The rate of application is a function of the spoil pH to be treated and the neutralization capacity of the fly ash to be utilized. The higher the neutralization capacity of the fly ash, the less amount required to raise the pH of the strip mine spoils. The neutralization capacity of the various sources and their proximity to the project site indicates that fly ash from the Mitchell Power Station will be the most economical source and should be utilized. Figure 17 indicates that the fly ash application rate to be utilized on this project will be a maximum of 200 tons per acre (448.3 metric tons/hectare) if the Mitchell Power Station fly ash is utilized.

Fly Ash Substitution: The utilization of a different fly ash source other than that recommended would require the determination of the neutralization capacity of this substitute fly ash source and the establishment of its equivalent conversion factor. The equivalent conversion factor must then be multiplied times the application rate determined from Figure 17. The equivalent conversion factors for other fly ash sources tested are shown on Table 9 and indicate that at least twice the amount of fly ash will be required if two of the other sources tested are substituted or used in lieu of the Mitchell Station fly ash source. Because the application rate of the other sources tested are higher than the Mitchell Station, any substitution for the additional tonnage, transportation charges, and incidental work thereto should be at the expense of the contractor.

Control of Fly Ash:

Quantity - The specified amount of fly ash to be applied will be controlled by certified weight slips furnished by the Contractor and the thickness of the fly ash evenly spread over the surface prior to mixing. Generally 1 inch (2.54 centimeters) of fly ash thickness per acre (0.405 hectare) represents 136 tons (123.4 metric tons) of fly ash with a bulk density of 75 pounds (34 kilograms) per cubic foot (28.4 cubic decimeters). Because the thickness of the layer will depend upon the bulk density of the fly ash as spread on the site, density tests must be performed for control.

Quality - The fly ash source to be used by the contractor should be tested to determine if fly ash neutralization capacity conforms to the neutralization capacity and subsequent application rate recommended in this report. It is recommended that a neutralization capacity test be performed for each 500 tons (450 metric tons) delivery to the site.

Storage - Because the availability of a large quanitity of fly ash may not be readily available over a short time period and also to expedite the placement of the fly ash in a continuous process, a fly ash storage area should be designated on the contract drawings.

Compliance - It shall be the contractor's responsibility to apply the fly ash at the recommended rates and all loss of materials due to erosion (air and water) must be satisfactorily replaced by the contractor at no additional cost.

SEEDING

Seeding requirements for the project were developed in cooperation with the Commonwealth of Pennsylvania Bureau of State Parks and the Washington County Agriculture Agent. The general species of grasses and legumes to be planted on the fly ash spoil mixture in the demonstration area are:

Tall Fescue

Common Clover

Orchard Grass

Common Rye Grass

Common Timothy

Crown Vetch

Birdsfoot Trefoil

The use of Crown Vetch will be limited to cut slopes whereas Birdsfoot Trefoil will be primarily specified within channel sections. The grass-hay varieties will be specified for relatively flat sloping areas.

SAMPLING AND TESTING

Samples from the following areas should be obtained for pH, grain size and moisture retention determination in order for documentation and comparison:

Strip mine spoils approved for application of fly ash.

Strip mine spoils after the application of fly ash.

Strip mine spoil-fly ash mixtures, 1 year after the application of fly ash.

Strip mine spoils from other construction areas of Hillman State Park outside the Demonstration area.

CONTINUING WATER QUALITY MONITORING

Existing Stations: It is recommended that the present weir sampling stations located throughout Hillman State Park be maintained. This will provide additional water quality data to interpret the effect the reclamation construction has had on the park stream. The projected time for monitoring is 9 months during design and construction in the demonstration area and 18 months afterwards. This time period should encompass one or two additional growing seasons on the other areas of Hillman Park in which reclamation work has been performed.

Additional Station: An additional sampling station located at former sampling station 5 would provide information on the effects of construction undertaken outside the demonstration project area in Subwatershed areas 3-8, 3-9 and a portion of 3-10. This data would be useful in comparison of the water quality from outside the demonstration area to areas within the demonstration project.

Continuous Monitor: The instrumentation as proposed for the continuous monitor will provide data concerning pH, conductivity and flow of waters being discharged from the majority of the demonstration area. The water quality data assembled to date indicates the pH of the water at the proposed location of the continuous monitor is near pH 7. A small variance in this pH is expected. The conductivity of the water will probably change due to the exposure of formerly buried spoil material. However, this exposure would only affect the water for a short period which is expected to occur between completion of the cut excavation and the application of the fly ash. The estimated construction costs for the continuous monitor and associated embankment monitor, housing, instruments, power source and flow pipes, anticipating both high and low flow parameters, is about $39,000. It is the opinion of the Consultant that instead of installing the instrumentation as proposed for the continuous monitor, a stilling well be constructed at Station 17A for the purpose of measuring continuous flow and weekly sampling. In addition to sampling at Station 17A on a weekly basis, sampling at Station 10 and Station 4B should also be conducted on a weekly basis for the 30 month construction and post-construction monitoring period. The weekly samples should be tested for pH, acidity, alkalinity, iron, sulfate, aluminum, manganese, calcium, magnesium, sodium, potassium, and phosphorous. This is because these constituents are now present in the strip mine spoils and in the fly ash. It would be noteworthy to determine the percent increase in these constituents and its effect on the survival of grasses, legumes, and aquatic life. The weekly samples from Station 17A should also include testing for turbidity and suspended solids.

SECTION VIII

COST ESTIMATE

SUMMARY OF ESTIMATED COSTS TO COMPLETE PROJECT

Construction Costs	$ 900,000.00
Fly Ash	$ 70,000.00
Engineering Phase II	$ 17,000.00
Engineering Phase III	$ 29,500.00
Carry Over From Phase I (Additional Sampling and Testing or Continuous Monitor)	$ 20,000.00
TOTAL ESTIMATED COST:	$1,036,500.00

The above items do not include any charges for Commonwealth of Pennsylvania salaries and expenses.

CONSTRUCTION COST ESTIMATE

From Project SL 130-2, Hillman State Park Mine Drainage Pollution Survey, Appendix C, Table I, the estimated earthmoving quantities in the demonstration area represented approximately 61% of an area which had an estimated construction cost of $772,000 for reclamation. Thus, the estimated cost of construction for the original Hillman State Park demonstration area was 61% of $772,000 or $471,000. These figures represent 1972 prices and do not include reclamation in subwatershed areas 1-1 and 1-29 subsequently added to the demonstration project area. A construction cost estimate based on the Pre-Final Design Submission (August, 1974) was $900,000 for the general construction contract designed as Commonwealth of Pennsylvania Project SL 130-2-1.1B.

This cost estimate does not include the acquisition or transportation of fly ash. Details of the estimated quantities and approximate unit costs for the various items necessary for reclamation are shown on Table 11. The unit costs used are based on bids received in the adjacent reclamation areas within Hillman State Park.

TABLE 11 - ESTIMATE OF CONSTRUCTION COSTS

Item Description	Quantity	Unit Cost	Total
Clearing and Grubbing	178 Acres (72 Hectares)	$ 75.00	$ 13,350
Earthwork	1,210,000 Cubic Yards (925,000 Cubic Meters)	$ 0.65	$ 786,500
Surface Compaction	Estimated		
Drainage Facilities:			
36" ø RCC Pipe (9.14 Decimeter)	36 Linear Feet (11 Meters)	$ 30.00	$ 1,080
Endwalls	2 Each	$500.00	$ 1,000
Jute Matting	4,250 Square Yards (3,550 Square Meters)	$ 1.00	$ 4,250
Dump Rock Cutter	780 Square Yards (650 Square Meters)	$ 15.00	$ 11,700
Riprap	240 Square Yards (200 Square Meters)	$ 25.00	$ 6,000
Fly Ash Placing and Mixing	178 Acres (72 Hectares)	$ 60.00	$ 10,680
Soil Treatment, Fertilizer and Seeding	178 Acres (72 Hectares)	$290.00	$ 51,620
Erosion and Sedimentation Measures	Estimated	Lump Sum	$ 10,000

FLY ASH ESTIMATE

In order to estimate the tonnage of fly ash needed for the demonstration site, an average spoil pH of 4.0 was used. It is anticipated that 178 acres will require treatment which results in 22,250 tons (20,185 metric tons over 72 hectares). With the transportation costs estimated at about $3.15 per ton ($3.47 per metric ton), the estimated cost of fly ash transportion is $70,000.

CONSTRUCTION DESIGN COSTS

The costs for design of the construction contract, including layout of reference points plus periodic field consultation, is estimated to be $53,000 and is being performed by the Consultant for the Commonwealth of Pennsylvania under Contract SL 130-2-1, but is not included in the summary of estimated cost to complete the project because this work is primarily being performed simultaneously with Phase I of this project.

ENGINEERING COSTS FOR THE DEMONSTRATION PORTION

The following engineering costs have been established for the remaining phases of the demonstration project:

Phase II	$17,128.00
Phase III	$29,553.00

The major engineering items of Phase II are obtaining water samples on a monthly basis, laboratory testing and engineering analysis of this phase. The major engineering items of Phase III are similar to the above listed and included in addition to the preparation of a final report which summarizes the results and findings for the demonstration project.

Phase II and Phase III Commonwealth of Pennsylvania salaries and expenses are not included in the above total.

There will be a carry-over to Phase II of $20,000 budgeted in Phase I for the construction of a continuous monitor installation. If the Consultant's recommendations concerning both the construction of a stilling well for continuous flow measurements and the collection of additional sampling and testing are accepted in lieu of that previously proposed for the continuous monitor, the monies previously scheduled will be budgeted for this purpose. If it is desired to have a continuous monitor installed as proposed, then an additional sum in the amount of approximately $19,000 must be budgeted for the demonstration project.

SECTION IX

APPENDIX

STATION 2

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	366	7.5	20	88	60	264	1350	5900	0.3	1	1.2	5	5	18
6/24/74	235	7.6	30	85	74	209	1650	4660	0.2	1	3	8	6	17
7/2/74	182	6.7	48	105	50	109	1550	3390	0.3	1	3	7	6	13
7/8/74	138	7.4	45	75	60	99	1750	2900	0	0	0	0	6	10
7/15/74	159	7.5	23	44	68	130	1560	2980	0.1	0	0.8	2	4	8
7/23/74	297	7.6	34	121	89	317	1340	4780	0.3	1	2.0	7	2	7
7/29/74		7.8	14		86		1650		0.2		1.9		5	
8/6/74	108	7.5	0	0	68	88	1750	2270	0.3	0	1.2	2	4	5
8/14/74	101	7.8	0	0	94	114	1620	1970	0.2	0	0.8	1	3	4
8/20/74	37	7.2	0	0	85	38	1820	810	0.2	0	0.7	0	3	1
8/30/74	402	7.7	0	0	77	372	1320	6370	0.1	0	0	0	2	1
9/7/74	182	7.6	0	0	85	186	1450	3170	0.2	0	3	7	6	13
9/10/74	159	7.1	0	0	76	145	1580	3020	0.2	0	4	8	6	11
13 WEEK AVERAGE	197	7.5	16	38	75	177	1570	3710	0.2	0	2	4	4	9
* PREVIOUS WATER QUALITY	497	6.4	179	1067	55	263	2270	14,500	0.2	1	0.8	5		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 10 Samples From 7/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day multiply by 0.4536

STATION 4B

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	366	6.3	86	378	16	70	1350	5930	0.3	1	4	18	11	48
6/24/74	265	4.8	156	496	0	0	2000	6370	8	25	7	22	21	67
7/2/74	235	5.1	193	545	2	6	1750	4940	7	20	8	23	12	34
7/8/74	138	4.5	333	552	0	0	2200	3650	6	10	11	18	21	35
7/15/74	159	5.0	224	428	3	5	1850	3530	1.9	4	7	13	16	31
7/23/74	481	6.7	12	69	41	237	1550	8950	3	17	4	23	9	52
7/29/74		4.6	344		0		2300		8		17		21	
8/6/74	101	4.7	96	116	0	0	2800	3400	8	10	14	17	22	27
8/14/74	93	4.6	100	112	0	0	2450	2740	7	8	15	17	24	27
8/20/74	108	4.6	58	75	0	0	2500	3240	3	4	15	19	23	30
8/30/74	441	7.4	0	0	29	154	1280	6780	0.6	3	2	11	8	42
9/7/74	159	5.1	35	67	5	10	1900	3630	6	11	11	21	21	40
9/10/74	138	4.8	30	50	5	8	1980	3280	5	8	11	18	22	36
13 WEEK AVERAGE	224	5.2	128	344	8	22	1990	5350	5	13	10	26	18	48
PREVIOUS WATER QUALITY	284	5.2	383	1306	31	106	2690	9180	1.3	4	1.9	6		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - Stations 4 and 4A combine to run into Station 4B. Stations 4 and 4A - 14 Samples from 7/70 through 7/71. For Station 4 - 11 Samples from 10/70 through 7/71 for Station 4A.

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 6

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	107	7.6	0	0	92	118	1480	1900	0.1	0	0.2	0	0	0
6/24/74	79	7.6	0	0	78	74	2000	1900	0	0	0.2	0	1	1
7/2/74	61	7.1	16	12	78	57	1750	1280	0.3	0	0.6	0	1	1
7/8/74	51	7.0	0	0	76	47	1980	1210	0	0	0	0	1	1
7/15/74	61	7.5	0	0	76	56	2000	1470	0.1	0	0	0	0	0
7/23/74	86	7.7	6	6	80	83	1780	1840	0.3	0	0.2	0	1	1
7/29/74		7.6	0		80		2250		0.2		0.1		1	
8/6/74	37	7.4	0	0	75	33	2050	910	0.3	0	0.1	0	1	0
8/14/74	29	7.5	0	0	79	28	2280	790	0.4	0	0	0	1	0
8/20/74	107	7.8	0	0	77	99	2220	2850	0.2	0	0.1	0	1	1
8/30/74	107	7.8	0	0	86	111	1380	1770	0	0	0	0	1	1
9/7/74	69	7.4	0	0	93	77	1480	1230	0.3	0	0.2	0	1	1
9/10/74	51	7.2	0	0	93	57	1700	1040	0	0	0	0	1	1
13 WEEK AVERAGE	70	7.5	2	2	82	69	1870	1570	0.2	0	0.1	0	1	1
* PREVIOUS WATER QUALITY	104	6.3	272	339	83	98	2480	3080	0.1	0.1	0	0		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 14 Samples from 7/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 10

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	203	6.9	66	161	19	46	2250	5490	1.1	3	0.4	1	26	63
6/24/74	117	7.0	72	101	19	27	2350	3300	0.5	1	0.1	0	38	53
7/2/74	86	6.6	225	232	33	34	2380	2460	0.6	1	0.2	0	29	30
7/8/74	51	6.8	265	162	28	17	2580	1580	0.8	0	0.2	0	29	18
7/15/74	101	7.1	182	221	37	45	2200	2670	0.8	1	0.2	0	28	34
7/23/74	225	7.1	32	86	30	81	2050	5540	1.4	4	0.3	1	26	70
7/29/74		7.1	200		38		2580		1.8		0.1		34	
8/6/74	46	7.0	3	2	41	23	2700	1490	1.0	1	0.2	0	35	19
8/14/74	37	7.2	4	2	43	19	2550	1130	0.2	0	0.1	0	22	10
8/20/74	33	7.4	0	0	49	19	2750	1090	0.6	0	0	0	39	15
8/30/74	225	7.6	0	0	31	84	1580	4270	0.8	2	0.1	0	20	54
9/7/74	93	7.2	0	0	56	63	2200	2460	1.2	1	0.2	0	37	41
9/10/74	67	6.9	0	0	55	44	2380	1920	0.8	1	0.1	0	38	31
13 WEEK AVERAGE	107	7.1	81	104	37	48	2350	3020	0.9	1	0.2	0	31	40
* PREVIOUS WATER QUALITY	156	4.9	564	1056	16	29	3510	6490	0.5	1.1	1.2	2.6		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 14 Samples from 7/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day Multiply by 0.4536

STATION 10A

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	124	6.4	182	271	14	21	2450	3650	2.0	3	3	4	42	63
6/24/74	105	6.4	103	130	14	18	2700	3400	1.4	2	2.0	3	47	59
7/2/74	79	7.1	122	116	16	15	820	780	1.6	2	3	3	32	30
7/8/74	73	6.6	308	270	33	29	2820	2470	0.2	0	1.4	1	37	32
7/15/74	93	6.8	250	279	46	51	2580	2880	0.4	0	1.4	2	36	40
7/23/74	244	7.0	20	59	45	132	2120	6210	1.8	5	1.0	3	29	85
7/29/74		6.9	140		48		2800		3		1.5		40	
8/6/74	46	6.8	4	2	51	28	2800	1550	4	2	1.3	1	39	22
8/14/74	37	6.9	2	1	65	29	2800	1240	4	2	1.0	0	40	18
8/20/74	41	7.4	0	0	63	31	3050	1500	6	3	2.0	1	48	24
8/30/74	167	7.2	0	0	34	68	1720	3450	0.2	0	1.1	2	24	48
9/7/74	73	6.8	2	2	63	55	2420	2120	4	4	4	4	47	41
9/10/74	67	6.5	0	0	67	54	2450	1970	0.6	0	6	5	44	35
13 WEEK AVERAGE	96	6.8	87	100	43	50	2430	2800	2	3	2	3	39	45
* PREVIOUS WATER QUALITY	432	4.8	769	3220	23	54	4530	21200	1.3	7	1.3	7		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - Station 12A - 15 Samples from 7/70 through 7/71

Initial Survey Station 12A Upstream of Current 10A

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 12

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	61	6.8	114	84	32	23	2350	1720	2.0	1	1.0	1	34	25
6/24/74	67	6.9	66	53	137	110	2800	2250	1.3	1	0.5	0	41	33
7/2/74	46	6.9	280	155	68	38	2700	1490	1.4	1	0	0	32	18
7/8/74	46	7.0	340	188	53	29	3100	1710	1.6	1	0.1	0	43	24
7/15/74	29	6.8	284	99	72	25	2980	1040	0.3	0	0	0	40	14
7/23/74	101	6.6	20	24	38	46	1920	2330	5	6	0.3	0	4	5
7/29/74		6.8	180		66		2680		4		0		42	
8/6/74	17	7.3	2	0	76	16	3300	670	5	1	0.3	0	44	9
8/14/74	10	6.8	2	0	82	10	3120	370	6	1	0	0	44	5
8/20/74	8	7.8	0	0	86	8	3200	310	7	1	0.1	0	50	5
8/30/74	51	7.3	0	0	60	37	1820	1110	0.3	0	0.5	0	24	15
9/7/74	37	6.9	0	0	96	43	2450	1090	6	3	0.1	0	43	19
9/10/74	41	6.6	2	1	94	46	2620	1209	3	1	0.1	0	47	23
13 WEEK AVERAGE	43	7.0	99	51	74	38	2700	1390	3	2	0.2	0	38	20
* PREVIOUS WATER QUALITY	91	4.6	820	895	6	8	4000	4380	1.5	1	1.6	1		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 12 Samples from 10/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 16

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	78	6.8	118	106	328	311	3500	3320	0.4	0	0	0	9	9
6/24/74	79	6.7	52	49	329	312	3700	3510	0.3	0	0	0	6	6
7/2/74	73	6.6	172	151	315	276	3500	3070	0.1	0	0	0	7	6
7/8/74	78	6.6	329	288	316	277	3500	3070	0.1	0	0	0	6	5
7/15/74	67	6.6	280	225	320	257	3700	2980	0.1	0	0	0	7	6
7/23/74	73	7.0	71	62	326	286	2980	2610	2.0	2	0.1	0	6	5
7/29/74		6.7	92		334		3550		3		0.1		9	
8/6/74	61	6.7	0	0	328	240	3700	2710	3	2	0	0	7	5
8/14/74	56	6.8	0	0	338	227	3500	2350	3	2	0.1	0	6	4
8/20/74	56	7.5	12	8	319	215	3380	2270	4	3	0.1	0	7	5
8/30/74	56	7.1	32	22	317	213	3380	2270	0	0	0	0	5	3
9/7/74	51	6.8	20	12	340	208	3300	2020	0.2	0	0	0	8	5
9/10/74	51	6.4	28	17	361	221	3300	2020	0	0	0	0	8	5
13 WEEK AVERAGE	65	6.8	92	72	329	257	3460	2700	1	1	0	0	7	5
* PREVIOUS WATER QUALITY	36	6.1	364	157	250	110	4250	1840	1.1	1	0	0		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 14 Samples from 7/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 17

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	130	6.9	107	167	192	300	2800	4370	3	5	7	11	41	64
6/24/74	117	7.0	165	232	144	202	2800	3930	6	8	0.5	1	35	49
7/ 8/ 74	117	6.8	200	281	160	225	2820	3960	0.2	0	0.2	0	22	31
7/ 8/ 74	117	6.9	166	233	164	230	2820	3960	3	4	0	0	28	39
7/15/74	117	6.8	162	228	149	209	2820	3960	0.2	0	0.8	1	28	39
7/23/74	130	7.0	47	70	125	185	2380	3720	3	5	9	14	15	23
7/29/74		7.1	93		202		2450		6		13		4	
8/ 6/ 74	101	7.2	0	0	206	250	2700	3280	6	7	13	16	22	27
8/14/74	101	7.3	0	0	229	278	2700	3280	4	5	8	10	19	23
8/20/74	117	7.4	0	0	238	334	2820	3960	4	6	7	10	19	27
8/30/74	145	7.4	3	5	178	310	2450	4270	0.1	0	0.1	0	16	28
9/ 7/ 74	101	7.2	8	10	233	283	2580	3130	3	3	0.9	1	22	27
9/10/74	101	6.9	12	15	226	274	2680	3250	0.6	1	0.1	0	24	29
13 WEEK AVERAGE	116	7.1	74	103	188	262	2680	3730	3	4	5	6	23	32
* PREVIOUS WATER QUALITY	11	5.8	432	576	112	143	4020	5520	2.3	3	0.7	1		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 14 Samples from 7/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 17A

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74														
6/24/74		7.4	0		148		2450		0.3		1.2		8	
7/2/74		7.1	117		80		2530		0.3		1.8		7	
7/8/74		7.3	141		115		2700		0		0.3		7	
7/15/74		7.4	84		99		2480		0.2		1.0		6	
7/23/74		7.4	0		106		2200		0.4		0.6		5	
7/29/74		7.6	74		138		2380		0.3		0.4		8	
8/6/74	175	7.7	0	0	136	286	2450	5150	0.6	1	0.6	1	4	8
8/14/74		7.7	0		146		2450		0.1		0.1		4	
8/20/74	149	7.4	0	0	140	251	2680	4800	0.2	0	0.2	0	4	7
8/30/74	510	7.5	0	0	97	594	2080	12740	0.2	1	0.3	2	4	25
9/7/74	190	7.5	2	5	144	329	2200	5020	0.4	1	0.8	2	1	2
9/10/74	172	7.3	0	0	153	316	2180	4500	0.2	0	0.8	2	6	12
13 WEEK AVERAGE	239	7.4	35	100	125	359	2400	6890	0.3	1	0.7	2	5	14
* PREVIOUS WATER QUALITY	524	6.0	328	2060	81	400	3770	24880	0.7	4	0.2	1		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 10 Samples from 10/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 18A

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	86	7.6	0	0	72	74	2120	2190	0.2	0	0.1	0	0	0
6/24/74	67	7.6	0	0	86	69	2350	1890	0.1	0	0	0	0	0
7/2/74	51	7.4	0	0	94	58	2450	1500	0.1	0	0	0	0	0
7/8/74	41	8.0	28	14	60	30	1520	750	0.1	0	0	0	0	0
7/15/74	51	7.5	56	34	93	57	2280	1400	0.6	0	0	0	0	0
7/23/74	73	7.6	0	102	102	89	2120	1860	0.2	0	0.1	0	0	0
7/29/74		7.6	0		116		2450		0.1		0		0	
8/6/74	26	7.6	0	0	115	36	2450	770	0.2	0	1.9	1	0	0
8/14/74	19	7.6	0	0	115	26	2550	580	0.3	0	0.1	0	1	0
8/20/74	22	7.8	0	0	116	31	2500	660	0.1	0	0	0	0	0
8/30/74	73	7.7	0	0	88	77	2120	1860	0	0	0	0	0	0
9/7/74	33	7.5	0	0	100	40	2020	800	0	0	0	0	0	0
9/10/74	33	7.2	1	0	111	44	2200	870	0.1	0	0	0	0	0
13 WEEK AVERAGE	48	7.6	7	4	98	56	2240	1290	0.2	0	0.2	0	0	00
* PREVIOUS WATER QUALITY		6.1	186		37		2950		0.5		0.2			

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 5 Samples from 7/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 32

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	1124	7.9	21	283	104	1404	1520	20520	0.2	3	0.1	1	3	41
6/24/74	819	7.9	0	0	110	1082	1920	18890	0.2	2	0.2	2	3	30
7/2/74	459	7.7	88	485	112	617	2250	12400	0.1	1	0	0	4	22
7/8/74	366	7.7	27	119	119	523	2120	9320	0	0	0	0	3	13
7/15/74	633	7.6	35	266	96	730	2000	15200	0.1	1	0	0	3	23
7/23/74	829	7.9	0	0	122	1215	2000	19910	0.2	2	0.2	2	3	30
7/29/74		7.9	16		136		2050		0.2		0.1		2	
8/6/74	259	8.0	1	3	132	411	2280	6840	0.2	1	0.6	2	2	6
8/14/74	259	8.1	0	0	146	454	2200	6840	0.3	1	0.1	0	2	6
8/20/74	274	8.2	0	0	126	415	2280	7500	0.1	0	0	0	2	7
8/30/74	1412	7.6	0	0	95	1611	1480	25100	0.1	2	0.1	2	2	34
9/7/74	449	7.8	0	0	137	739	1680	9060	0.1	1	0.1	1	3	16
9/10/74	386	7.6	0	0	146	677	2090	8810	0	0	0.1	0	2	9
13 WEEK AVERAGE	606	7.8	14	102	122	888	1970	14340	0.1	1	0.1	1	3	22
* PREVIOUS WATER QUALITY	1065	6.4	139	1780	70	837	2940	26100	0.3	2	0.1	1		

Source - Hillmon State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 9 Samples from 12/70 through 7/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 35

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	864	7.5	22	228	39	405	1000	10380	1.7	18	3	31	8	83
6/24/74	516	7.0	94	583	18	112	1350	8370	2	12	4	25	10	62
7/2/74	386	7.4	65	301	50	232	1140	5280	1.6	7	1.7	8	9	42
7/8/74	199	7.5	104	249	66	158	2280	5450	0	0	0.3	1	12	29
7/15/74	269	7.1	25	81	34	110	880	2840	0.5	2	1.7	5	7	23
7/23/74	1047	6.1	179	2251	6	75	1780	22380	3	38	18	226	21	264
7/29/74		7.4	94		40		1620		0.5		4		14	
8/6/74	185	7.5	0	0	33	73	1700	3780	1.5	3	4	9	15	33
8/14/74	146	7.5	2	4	20	35	1850	3240	0.3	1	0.1	0	13	23
8/20/74	185	7.7	0	0	27	60	1980	4400	0.5	1	0.1	0	7	16
8/30/74	1279	7.5	0	0	21	323	1200	18430	0.6	9	1.2	18	6	92
9/7/74	521	7.5	0	0	65	407	1120	7010	0	0	0	0	9	56
9/10/74	315	7.3	0	0	51	193	1300	4920	0.2	1	0.4	2	11	42
13 WEEK AVERAGE	493	7.3	45	266	36	213	1480	8760	1	6	3	18	11	65
* PREVIOUS WATER QUALITY	2100	6.3	232	2350	28	280	1610	40610	1.0	25	0.6	15		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 3 Samples from 1/71 through 3/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536

STATION 40

DATE SAMPLED	FLOW GPM	pH	ACIDITY		ALKALINITY		SULFATES		TOTAL IRON		ALUMINUM		MANGANESE	
			CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC MG/L	LOAD LBS/DAY	CONC. MG/L	LOAD LBS/DAY
6/17/74	328	7.1	41	162	20	79	1580	6220	0.4	2	1.0	4	15	59
6/24/74	249	6.8	142	425	11	33	2000	5980	0.2	1	1.8	5	18	54
7/2/74	145	5.9	182	317	5	9	1850	3220	0.4	1	4	7	15	26
7/8/74	130	4.7	211	329	1	2	1520	2370	0.5	1	6	9	18	28
7/15/74	182	7.0	181	396	20	44	1980	4330	0.7	2	3	7	19	42
7/23/74	587	7.0	145	1022	22	155	2000	14100	5	35	13	92	19	134
7/29/74		6.0	185		4		2300		0.6		6		19	
8/6/74	86	7.4	1	1	26	27	2120	2190	0.8	1	5	5	20	21
8/14/74	37	7.2	2	1	19	8	2350	1040	0.4	0	3	1	18	8
8/20/74	73	7.5	0	0	27	24	2220	1950	0.5	0	0.3	0	20	18
8/30/74	819	7.0	0	0	29	285	1420	13970	0.1	1	0.5	5	16	157
9/7/74	130	7.3	1	2	31	48	1820	2840	0.3	0	1.9	3	20	31
9/10/74	107	7.0	0	0	28	36	1980	2544	0.1	0	3	4	19	24
13 WEEK AVERAGE	239	6.8	84	241	19	55	1930	5540	1	2	4	11	18	52
* PREVIOUS WATER QUALITY	560	5.4	337	2265	11	75	2940	20200	0.2	1	1.3	9		

Source - Hillman State Park Mine Drainage Survey SL 130-2 April 14, 1972

*Survey Sampling - 4 Samples from 2/71 through 5/71

Note: To Convert Lbs/Day to Kg/Day Multiply By 0.4536